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A REVISION OF THE NEARTIC SILPHINI AND NICROPHORINI BASED UPON THE FEMALE GENITALIA (COLEOPTERA, SILPHIDÆ)

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ITHACA, NEW YORK

The use of the female genitalia as a basis for identification of genera and species of Coleoptera has been greatly neglected. In some groups of beetles, however, the female genitalia apparently offer more diversity of form among species than do those of the male. Tanner in 1927 pointed out a growing necessity for a study of the genitalia of beetles for specific descriptions. The genitalia are naturally more constant within a species than other parts and they give the taxonomist a better concept of a species, and its subspecific forms and categories.

The purpose of this study is to present the comparative morphology of the female genitalia of the Neartic Silphini and Nicrophorini. It is hoped that the drawings, the key to the genitalia and the synopsis will be an aid to identification. No basic conclusions have been made as to relationships, although certain tendencies have been indicated.

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I am indebted to Professor M. H. Hatch of the University of Washington and to the United States National Museum for their generous loan of material for which I thank them sincerely.

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METHODS.—The methods used in this study are somewhat different from those used by Tanner. The beetle was first relaxed in hot water and the genitalia removed with a pair of forceps and boiled in caustic potash. They were then put in water and the mid-ventral membrane cut, the two lateral plates (the paraprocts) flattened out on each side of the dorsal plate (the proctiger) and the coxite bent out to the side of the valvifer so that the whole organ was flattened out. It was then mounted in balsam. This enables projection drawings to be made. It is essentially the same method as that used in studying the male genitalia of Lepidoptera.

SEXUAL DIFFERENCES.—In the female Silphini, the sutural angles of the elytra are very acute, whereas in the males they are generally but not always rounded. The hind femora are greatly enlarged in the males of *Silpha littoralis* L. and normal in size in the female sex. Little sexual differences is evident in *Thanatophilus truncata* Say.

In the Nicrophorini studied, the males have the eyes situated well forward on the head, the clypeus large and the fore tarsal pulvilli expanded, whereas in the females the eyes are placed well towards the back of the head, the clypeus is appreciably smaller and the fore tarsal pulvilli are simple.

SPECIES STUDIED

NEARTIC SPECIES.—A list of the species considered in this paper follows. Only a few forms of subspecific rank have been studied. Of those studied, however, some changes have had to be made in their ranking. Of the others, the opinion of other authors has been followed in considering their rank. In the case of *Nicrophorus pulsator* Gistel, and *Silpha tyrolensis* Leach, the evidence of their existence in the Neartic region is insufficient and they have not been included here.

NEARTIC SILPHINI AND NICROPHORINI

Silphini

Silpha L.
- *littoralis* L.
  - form *surinamensis* Fab.
  - ab. *bizonatus* Port.
- *disciocollis* Brulle
  - *analis* Chev.
  - *æquinoctialis* Gistel
  - *braziliensis* Dej.
  - *cayennensis* Berg. (nec Sturm.)
  - var. *elongata* Port.
  - var. *discreta* Port.

Thanatophilus Leach

Subgenus *Oiceoptoma* Leach
- *americana* L.
  - *peltata* Catesby
  - ab. *affinis* Kby.
  - *terminata* Kby.
  - *canadensis* Kby.
  - acc. *brunnipenis* Hatch
- *noveboracensis* Forst.
  - *marginalis* Fab.
  - *marginata* Kby.
- *quadripunctata* L.
  - *quadripunctulata* Muller
  - *quadrimaculata* Samouelle
  - var. *sexpunctata* Gerh.
  - ab. *bifasciata* Schulze.
- *inæqualis* Fab.
  - subsp. *rugulosa* Port.
  - *subrugata* Cherv. nom. nud.
  - acc. *bicolorata* Hatch
- *ramosa* Say
  - *cervaria* Mann.
  - *ænescens* Casey

Subgenus *Thanatophilus* s. str.
- *lapponica* Hbst.
  - *tuberculata* Germ.
  - subsp. *caudata* Say
  - *californica* Mann.
  - subsp. *granigera* Cherv.
- *trituberculata* Kby.
  - *sagax* Mann.
- *coloradensis* Wick.
  - *obalskii* Port.
- *truncata* Say
  - *mexicana* Cherv. in litt.

Blitophaga Reitt.
- *opaca* L.
  - *hirta* Schaff.
  - *villosa* Naezen
  - *tomentosa* Villers
  - var. *samnitica* Fiori
  - var. *binotata* Port.
- *bituberosa* Lec.

Nicrophorini

Nicrophorus Fabricius

Subgenus *Necrocharis* Portevin
- *carolinus* Fab.
  - *mediatus* Fab.
  - ab. *mysticallis* Ang.
  - ab. *scapulatus* Port.
  - ab. *dolosus* Port.
  - ab. *floridæ* Hatch
  - ab. *krautwurini* Hatch
  - ab. *lunulatus* Hatch
  - ab. *nebraskæ* Hatch

Subgenus *Nicrophorus* s. str.
- *orbicollis* Say
  - *halli* Kby.
  - *quadrisignatus* Cast.

humator Fab.
sulactus Fisch.
paratype of *grandior* Angell
var. *atricornis* Meier.
ab. *maculosus* Meier.
ab. *rubroplearalis* Delah.
delahoni Schilsky i. litt.
ab. *signiceps* Delah.
subsp. *tenuipes* Lewis
sayi Cast.
lumulatus Gistel
lunatus Lec.
luniger G. & H.
marginatus Fab.
requiscator Gistel
montezumæ Matt.
ab. *cordiger* Port.
ab. *sanjuanæ* Hatch
ab. *engelhardti* Hatch
ab. *leachi* Hatch
vespilloides Hbst.
mortuorum Fab.
fractus Port.
ab. *andrewesi* Port.
ab. *aurora* Motch.
hebes Kby.
pygmæus Kby.
vespilloides Lec. (nec. Hbst.)
defodiens Mann.
disjunctus Wil.-Ellis
ab. *humeralis* Hatch
ab. *tristis* Port.
ab. *steinfeldi* Smirnov.
ab. *maculatus* Wil.-Ellis
ab. *altumi* Westh.
ab. *subfasciatus* Port.
ab. *subinterruptus* Pic.
var. *borealis* Port.
var. *sylvaticus* Reitt
ab. *sylvivagus* Reitt
ab. *ruber* Hatch
ab. *nearticus* Hatch
ab. *nicolayi* Hatch
ab. *oregonesis* Hatch
subsp. *defodiens* Mann.
nunemacheri Hatch (nec. Port.)
ab. *binotoides* Hatch
binotatus Hatch (nec. Port.)
ab. *conversator* Walk.
defodiens var. *b.* Mann.
lateralis Port.
pollinctor Lec. (nec. Mann.)
ab. *pacificæ* Hatch
ab. *walkeri* Hatch
conversator Port. (nec. Walk.)
ab. *gaigei* Hatch
ab. *kadjakenis* Port.
ab. *mannerheimi* Port.
ab. *binotatus* Port.
plagiatus Mots.
vespillo L.
vulgaris Fab.
cadaverinus Gravenh.
curvipes Duftschm.
ab. *faureli* Fauconnet
ab. *varendorffi* Westh.
ab. *bolsmanni* Westh.
ab. *æthiops* Scheicher
ab. *minor* Westh.
ab. *germani* Hatch

americanus Oliv.
grandis Fab.
virginicus Frol.
melsheimeri Kby.
hybridus Hatch & Angell
var. *minesotianus* Hatch
nigritus Mann.
var. *ruficornis* Mots.
pustulatus Hers.
bicolor Newn.
tardus Mann.
ab. *coloradensis* Hatch
ab. *noveboracensis* Hatch
ab. *fasciatus* Port.
ab. *unicolor* Port.
investigator Zett.
ruspator Er.
infodiens Mann.
confossor Mots.
microcephalus Thoms.
pustulatus Horn. (nec. Hers.)
labiatus Mots.
vestigator Gyll. (nec. Hers.)
subsp. *investigator* Zett.
ab. *suturalis* Mots.
infodiens var. *b.* Mann.
ab. *funeror* Reitt.
ab. *funerator* Faur.
var. *variolosus* Port.
ab. *intermedius* Reitt.
ab. *jamezi* Hatch
ab. *lutescens* Port.
subsp. *maritimus* Guer.
aleuticus Guer.
pollintor Mann.
sibiricus Mots.
infodiens var. *c.* Mann.
ab. *martini* Hatch
ab. *clarencei* Hatch
ab. *sitkensis* Hatch
ab. *massetti* Hatch
ab. *grahami* Hatch
ab. *charlottei* Hatch
ab. *particeps* Fisch
ab. *japani* Hatch
tomentosus Web.
velutinus Fab.
ab. *communis* Hatch
ab. *elongatus* Hatch
ab. *angustefasciatus* Port.
ab. *splendens* Hatch
ab. *brevis* Hatch
var. *aurigaster* Port.
germanicus L.
listerianus Fourer
ab. *specious* Schultze
ab. *bimaculatus* Steph.
ab. *frontalis* Fisch.
ab. *fassifer* Reitt.
ab. *apicalis* Kraatz
var. *ruthenus* Mots.
grandior Ang.
guttula Mots.
subsp. *guttula* Mots.
ab. *ruficornis* Mots.
ab. *sanfranciscæ* Hatch
ab. *punctatus* Hatch
ab. *shastæ* Hatch
ab. *hypomerus* Hatch
ab. *lajollæ* Hatch
ab. *vandykei* Ang.
ab. *quadriguttatus* Ang.
ab. *kuschei* Hatch

mexicanus Matt.
hecate Bland
ab. *wallisi* Hatch
ab. *californiæ* Hatch
ab. *intermedius* Hatch
ab. *disjunctus* Port.
ab. *woodgatei* Hatch
ab. *phoenix* Hatch
ab. *novamexicæ* Hatch
ab. *rubripennis* Port.
ab. *rubrissimus* Hatch
ab. *immaculosis* Hatch
obscurus Kby.
melsheimeri Lec.
ab. *discontinus* Hatch
ab. *ruber* Hatch

EXOTIC FORMS AND THEIR RELATIONSHIP TO NEARTIC SPECIES.—The following list of species are exotic forms of which the female genitalia have been studied. The first name in each group is that of the type for the genus or subgenus, or it is a typical neartic species of that group. The next names are those studied with the generic or subgeneric name as used by other authors following it, if it differs from the names employed in this paper.

Silpha littoralis L.
Silpha cayennesis Sturn.
Silpha bigutatta Phil.
Necrodes bigutatta Phil.
Paranecrodes biguttata Phil.
Thanatophilus (*Oiceoptoma*) *americana* L.
Thanatophilus thoracica L.
Silpha thoracica L.
Thanatophilus japonica Mots.
Silpha japonica Mots.
Thanatophilus obscura L.
Silpha obscura L.
Thanatophilus carinata Hbst.
Silpha carinata Hbst.
Thanatophilus lærigata Fab.
Silpha lærigata Fab.
Thanatophilus perforata Gbl.
Silpha perforata Gbl.
Thanatophilus atrata L.
Silpha atrata L.
Thanatophilus nigrita Creutz
Silpha nigrita Creutz
Thanatophilus granulata Oliv.
Silpha granulata Oliv.
Thanatophilus (*Thanatophilus*) *truncata* Say
Thanatophilus sinuatus Fab.
Silpha sinuatus Fab.
Thanatophilus terminata Hum.
Silpha terminata Hum.
Thanatophilus rugosus L.
Silpha rugosus L.
Blitophaga opaca L.
Blitophaga oblonga Kust.
Silpha oblonga Kust.
Blitophaga souverbiei Fairm.

Silpha souveriei Fairm.
Blitophaga orientalis Brulle
Silpha orientalis Brulle
Nicrophorus (*Nicrophorus*) *vespillo* L.
Nicrophorus prædator Reitt.
Nicrophorus rotundicollis Port.
Nicrophorus didymus Brulle
Nicrophorus interruptus Steph.

SYNOPSIS OF THE NEARTIC SILPHINI AND NICROPHORINI.—The following synopsis is meant to serve as a means of correlating the external characters with those of the genitalia.

TRIBES

Antennæ apparently of ten segments, the second segment being very short and more or less hidden in the tip of the first; elytra short and not covering more than the basal five tergites . . . . *Nicrophorini*
Antennæ clearly of eleven segments, the second not shortened; elytra, if short, covering more than the basal five tergites . . . . . *Silphini*

Genera *Silphini*

A. Occipital ridge prominent; eyes usually large and prominent; form usually elongate; labrum broadly emarginate; prothoracic spiracle sometimes exposed . . . . . *Silpha* L.
AA. Occipital ridge usually not prominent; eyes not large and prominent; labrum broadly or narrowly emarginate; prothoracic spiracle rarely exposed.
B. Eyes normal, protruding somewhat from the head; labrum broadly or somewhat narrowly emarginate, but never very narrowly emarginate unless the head is elongate; head normal or elongate, not short, round or compact . *Thanatophilus* Leach
BB. Eyes very small, not or only very slightly protruding from the head; head short, round, and compact; labrum very narrowly emarginate . . . . *Blitophaga* Reitt.

SILPHA

Pronotum oval, black; elytra usually with red apical spots forming a bar, sometimes with red basal markings or sometimes immaculate . *littoralis* L.
Pronotum transverse, yellowish-brown with a black central area; elytra immaculate . . . . *discicollis* Brulle

THANATOPHILUS

Sub-genera

Labrum broadly or narrowly emarginate; pronotum rarely tomentose, if tomentose, then orange with a black central area; head and mouth parts often elongate . . . . *Oiceoptoma* Leach

Labrum always very broadly emarginate; pronotum usually tomentose, if not, then elytra without prominent costæ; head and mouth parts never elongate . . . . . . *Thanatophilus* s. str.

Sub-genus *Oiceoptoma*

A. Pronotum orange or yellow with a black central area.
  B. Elytra rugose . . . . . *americana* L.
  BB. Elytra smooth.
    C. Costæ prominent . *novaboracensis* Frost.
    CC. Costæ obscure, elytra tan with four black spots and the scutellum black . . . *quadripunctata* L.

AA. Pronotum black.
  D. Elytra smooth . . . *inæqualis* Fab.
  DD. Elytra rugose . . *ramosa* Say

Sub-genus *Thanatophilus*

A. Pronotum tomentose; elytral costæ prominent.
  B. Intervals of the elytral costæ tuberculate *lapponica* Hbst.
  BB. Intervals of the elytral costæ flat.
    C. Two inner elytral costæ subequal throughout. *trituberculata* Kby.
    CC. Two inner elytral costæ nearly obsolete at the base. *coloradensis* Wick

AA. Pronotum glabrous, costæ obscure *truncata* Say

BLITOPHAGA

Surface pubescent; form more elongate . . *opaca* L.
Surface sparsely pubescent; form more oval . *bituberosa* Lec.

NICROPHORUS

A. Pronotum oboval, without distinct sculpturing and very narrowly margined (subgenus *Necrocharis*) . . . . . . *carolinus* L.

AA. Pronotum orbicular, transverse or cordate with distinct sculpturing and widely margined on the sides and back (subgenus *Nicrophorus* s. str.).
  B. Pronotum orbicular, widely margined at the sides and the base. *orbicollis* Say
  BB. Pronotum not orbicular.
    C. Pronotum sinuate at the sides, base nearly as wide as the apex, sides and base widely margined, not cordate.
      D. Metasternal epimeron tomentose.
        E. Hind tibia curved.
          F. Metatrochanter spine small and divergent; pronotum disc orange, margin black; front orange . . . . *americanus* Fab.
          FF. Metatrochanter spine large and convergent; pronotum black; front black . *sayi* Lap.

EE. Hind tibia straight.

G. Spine of the metatrochanter obscure; elytra immaculate *nigritis* Mann.

GG. Spine of the metatrochanter prominent.

H. Spine divergent; elytra with orange fasciæ . . . *pustulatus* Hersch.

HH. Spine convergent; elytra immaculate. *humator* Fab.

DD. Metasternal epimeron glabrous.

I. Elytra immaculate; hind tibiæ usually curved. *germanicus* L.

II. Elytra with orange fasciæ; hind tibia straight.

J. Three terminal segments of the antennæ black . *vespilloides* Hbst.

JJ. Three terminal segments of the antennæ orange.

K. Metasternal pubescence brown; abdominal pubescence black. *mexicanus* Matth.

KK. Metasternal pubescence yellow; abdominal pubescence brown. *investigator* Zett.

CC. Pronotum with base much narrower than the apex, sides strongly sinuate, cordate.

L. Metasternal epimeron glabrous *melsheimeri* Kby.

LL. Metasternal epimeron tomentose.

M. Thorax tomentose.

N. Thorax entirely tomentose. *tomentosus* Web.

NN. Thorax tomentose apically only. *vespillo* L.

MM. Thorax glabrous.

O. Basal segment of the antennal club black.

P. Hind tibia straight; disc of the pronotum punctate *guttula* Mots.

PP. Hind tibia arcuate; disc of the pronotum nearly smooth. *obscurus* Kby.

OO. Basal segment of the antennal club orange.

Q. Hind tibia arcuate *marginatus* Fab.

QQ. Hind tibia straight.

R. Ventral surface of the posterior tibia densely yellow tomentose .... *hecate* Bland.

RR. Ventral surface of the hind tibia sparsely black tomentose. *hybridus* Hatch & Ang.

GENERAL MORPHOLOGY OF THE GENITALIA.—The same terminology as that adopted by Tanner, which seems to be a usable interpretation of the relationship of the parts, has been used here.

The dorsal plate or proctiger (Pl. I, Fig. 3, p.) forms the upper surface of the genitalia. It has a terminal process (Pl. II, Fig. 8, pro.) sometimes elongate and spatulate, and may be bent at various angles. Frequently it has terminal hairs. It apparently serves as the dorsal guide. The paraprocts (Pl. I, Fig. 3, pp.) are lateral plates forming the sides and bottom of the organ. They sometimes bear setæ. The paraproct bears the valvifer (Pl. I, Fig. 3, vf.) which in turn bears the coxite (Pl. I, Fig. 3, c.). The valvifer is sometimes modified into a lateral guide (Pl. II, Fig. 8, l.g.) appearing claw-like and lobed (Pl. II, Fig. 8, l.) or it may be unmodified and possess setæ. The coxite is a hollow process which supports the stylus (Pl. I, Fig. 3, sty.) either terminally or laterally on the margin. The stylus is of various sizes and length and in some species it is expanded at the apex.

The proctiger is interpreted as a part of the tenth abdominal tergite. The paraprocts are probably parts of the ninth tergite with the styli, coxites and valvifers as appendages of the ninth segment. In this study only the ninth and tenth segments have been considered. The eighth segment consists of two more or less unmodified plates, the tergite and sternite.

KEY TO THE NEARTIC SILPHINI AND NICROPHORINI BASED ON THE FEMALE GENITALIA

1. Valvifer at most only slightly lobed, not developed into a curved process; proctiger never extended and lobed, (*Silphini*) ... .. (2).
 Valvifer with a well developed curved process and the proctiger usually extended and lobed. (*Nicrophorini* one genus *Nicrophorus* Fab.) (14).
2. Stylus apical or lateral; coxite without a lateral projection . . (3).
 Stylus lateral; coxite with a lateral projection. (*Blitophaga* Reitt.) (12).
3. Stylus always apical, stout, the diameter nearly that of the coxite; coxite stout and more or less uniform throughout. (*Silpha* L.) .... (4).
 Stylus apical or lateral, if apical, then very small, much smaller than the coxite and the coxite is much wider at the base than at the apex. (*Thanatophilus* Leach.) .... (5).

SILPHA

4. Coxite with two lateral connecting ridges; stylus broader at the apex. *littoralis* L.
   Coxite without ridges; stylus more uniform throughout. *discicollis* Brulle

THANATOPHILUS

5. Stylus apical or lateral, if lateral then the coxite beyond the stylus is not greatly flattened or lobed. Subgenus *Oiceoptoma* Leach . (6).
   Stylus always lateral; coxite beyond the stylus greatly flattened and slightly lobed. Subgenus *Thanatophilus* s. str. . (10).
6. Stylus apical . . . *4-punctata* L.
   Stylus lateral . . . (7).
7. Stylus long and angulate, nearly reaching the apical end of the coxite. *americana* L.
   Stylus short and not angulate, and much shorter than the portion of the coxite beyond the insertion of the stylus . (8).
8. Apical portion of the coxite beyond the base of the stylus twice the length of the stylus or less . . . (9).
   Apical portion of the coxite beyond the base of the stylus much more than twice the length of the stylus . . *ramosa* Say
9. Bridge (Pl. I, Fig. 3, br.) between the coxite and the valvifer wide; proctiger broadly rounded apically; stylus round at the apex. *novaboracensis* Forst.
   Bridge between the coxite and the proctiger narrow; proctiger more angular apically; stylus angulate at the apex . *inaequalis* Fab.
10. Stylus greatly enlarged at the apex, more than twice the width of the basal portion . . . *truncata* Say.
    Stylus enlarged at the apex, but much less than twice the width of the basal portion . . . (11).
11. Coxite with a prominent basal spine below the insertion of the stylus. *coloradensis* Wick.
    Coxite without a prominent basal spine below the insertion of the stylus . . . (12).
12. Stylus inserted on the ventral surface of the coxite so that there is apparently a lateral flap covering the base of the stylus. *lapponica* Hbst.
    Stylus inserted on the lateral surface of the coxite *trituberculata* Kby.

BLITOPHAGA

13. Stylus as long as the lateral lobe of the coxite . . . *bituberosa* Lec.
    Stylus much shorter than the lateral lobe of the coxite . . *opaca* L.

NICROPHORUS

14. Coxite with a terminal claw as long or longer than the stylus. (Subgenus *Neocrocharis* Port.) . . . *carolinus* L.

Coxite without a terminal claw, or if apparently present, then always much less than the length of the stylus. (Subgenus *Nicrophorus* s. str.) . . . . (15).

15. Proctiger lobe short and broad . . . . (16).
Proctiger lobe long and narrow, without an apical spatula. *marginatus* Fab.
Proctiger lobe medium in length and width, with or without an apical spatula . . . . (18).
16. Proctiger lobe bifurcate . . . *orbicollis* Say
Proctiger lobe not bifurcate . . . . (17).
17. Proctiger lobe truncate, without prominent apical ridge *humator* Oliv.
Proctiger lobe round, with prominent apical ridge. (Pl. II, Fig. 8, r.) . . . . *sayi* Lap.
18. Proctiger without an apical spatula . *vespilloides* Hbst.
Proctiger with an apical spatula . (19).
19. Coxite with a basal-lateral lobe; lobe of the claw of the valvifer longer than wide . . . *vespillo* L.
Coxite without a basal-lateral lobe; lobe of the claw of the valvifer always broader than long . . (20).
20. Coxite emarginate on the inner lateral margin *americanus* L.
Coxite not emarginate . . . (21).
21. Lobe of the proctiger sub-truncate . . . (22).
Lobe of the proctiger round . . . . (24).
22. Lobe of the proctiger greatly curved dorsally-ventrally (23).
Lobe of the proctiger slightly curved dorsally-ventrally *nigritus* Mann.
23. Spatula of the proctiger lobe broad *melsheimeri* Kby.
Spatula of the proctiger lobe narrow . . *hybridus* Hatch & Ang.
24. Lobe of the valvifer claw obscure . (25).
Lobe of the valvifer claw prominent . . . (27).
25. Coxite very narrow . . . . *hecate* Bland.
Coxite broad . . . . (26).
26. Proctiger lobe greatly curved dorsally-ventrally (28).
Proctiger lobe slightly curved dorsally-ventrally . . (29).
27. Lobe of the claw of the valvifer with setæ, spatula ridged. *germanicus* L.
Lobe of the claw of the valvifer without setæ, spatula not ridged. *pustulatus* Hers.
28. Apical margin of the base of the valvifer concave and nearly parallel with the basal margin . . . . *mexicanus* Matt.
Apical margin of the base of the valvifer nearly straight and not parallel with the basal margin . . . . *tomentosus* Web.
29. Spatula of the proctiger lobe oval . . . . *guttula* Mots.
Spatula of the proctiger lobe round . . . . (30).
30. Valvifer, exclusive of the lobe, square . . . . *obscurus* Kby.
Valvifer, exclusive of the lobe, trapizoidal . . . . *investigator* Zett.

DISCUSSION OF THE NEARTIC SILPHINI AND NICROPHORINI

GENERAL.—The tendencies pointed out here are based only on the species considered in this study and without comparison with other beetles.

On the basis of the female genitalia alone, the Silphini appear to be the more primitive of the two tribes and have been treated so here. But this conclusion is based on the assumption that simplicity of form, as seen in the Silphini, indicates primitiveness rather than reduction. The Nicrophorini are so closely linked together that it is difficult to tell anything about their phylogeny.

Silphini

The proctiger is simple, never lobed, usually with setæ; the paraproct is simple, essentially the same as that of the Nicrophorini, but with setæ. The valvifer at most is lobed only, usually with setæ; the coxite exhibits the greatest variation of the organ. It may have a basal lobe, or be uniform throughout. The stylus is attached to the coxite either terminally or laterally. The stylus is usually uniform in shape, but in some groups it is enlarged at the apex.

Silpha L.

Type: *Silpha littoralis* L., designated by Latreille 1810.

In this genus the stylus is terminal and stout, and is wider at the apex than at the base. The coxite is stout and uniform throughout. The proctiger, paraprocts and the valvifers are unmodified.

Silpha littoralis L.

This species is supposedly European, but the characters used to separate it from the Neartic *surinamensis* Fab. do not adequately separate the two. In the collection of the author there are specimens with immaculate elytra, and the genitalia of the two forms show no differences. Therefore *surinamensis* Fab. is a form of *littoralis* L. and not a distinct species. The genitalia of this species has a setigerous proctiger. The coxite is stout and with two ridges on the outer lateral surface which connect at the apex.

Silpha discicollis Brulle.

Proctiger with setæ; coxite without lateral ridges; stylus less enlarged at the apex.

Thanatophilus Leach

Type: *Silpha rugosa* L.

Coxite blade-like, flattened or uniformly triangular; stylus terminal or lateral, uniform throughout or enlarged at the apex.

Subgenus *Oiceoptoma* Leach

Type: *Silpha thoracica* L.

Coxite uniformly triangular with the stylus terminal, varying to coxite slightly flattened apically and the stylus lateral; stylus uniform throughout. Species as described in the key and synopsis.

Subgenus *Thanatophilus* s. str.

Coxite flattened at the apex, appearing blade-like and strongly curved on the outer side; stylus lateral and enlarged at the apex. The characters of the species are as presented in the key and synopsis.

Blitophaga Reitt.

Type: *Silpha opaca* L.

Coxite with basal lobe or tooth, terminal portion narrow and flattened; stylus small and lateral between the basal lobe and the apex of the coxite, never longer than the basal lobe. The characters of the species are as presented in the key and the synopsis.

Nicrophorini

The greatest difference between this tribe and the Silphini is in the modification of the proctiger. Here the proctiger is usually greatly extended and generally spatulate at the apex, nearly always with setæ. Also, the valvifer is quite different in appearance from that of the Silphini. It is greatly enlarged and extended, flattened and claw-shaped. The coxite is uniform, bearing the stylus terminally in all cases except *Nicrophorus carolinus* L. which has a lateral stylus. The paraproct is without setæ, but at times is ridged. The species of this genus are very closely related with the exception of *Nicrophorus carolinus*

L. which shows characters differing from the others and is placed in the subgenus *Necrocharis* Port.

Nicrophorus Fab.

Characters the same as those of the tribe. Type: *Nicrophorus vespillo* L., designated by Latreille, 1810.

Subgenus *Necrocharis* Port.

Type: *Nicrophorus carolina* L., one species only with characters as in the key and the synopsis.

Subgenus *Nicrophorus* s. str.

The species of the subgenus are all so closely related that they cannot be separated into species groups. The characters used in describing the species are inadequate. Color pattern has little or no value in separating the majority of the species. Their relationships depend entirely on what set of characters are used. Many aberrations have been described, but this is quite unnecessary and becomes extremely confusing, especially when they are not illustrated. Because of the great variation in the color pattern, almost any population can be described as a new aberration. Some changes have been made in the status of certain forms. Undoubtedly, when other forms are examined, more changes will be necessary. The following changes have been made on the basis of the characters presented in the key and synopsis:

Nicrophorus melsheimeri Kby. is a distinct species and not a synonym of *investigator* Zett.

Nicrophorus nigritus Mann. is a distinct species and not a subspecies of *investigator* Zett.

Nicrophorus hecate Bland. is a distinct species and not a subspecies of *guttula* Mots.

CONCLUSIONS

1. The female genitalia of Silphini and Nicrophorini present characters which serve to separate the species of the groups.

2. The two tribes have basically the same type of female genitalia, but they are two very distinct groups of genera.

3. Silphini tends to be more primitive than Nicrophorini.

4. The genera *Silpha, Thanatophilus, Blitophaga* and *Nicrophorus* are distinct groups of species.

5. The color patterns of *Nicrophorus* are not good specific characters and aberrations based on those characters are worthless.

6. The form and sculpturing of the elytra of *Silphini* do not show relationships between the species.

7. *Nicrophorus* offers no distinct species groups, and the species of the genus are very closely related.

BIBLIOGRAPHY

HATCH, M. H. Studies on the Silphinæ. Jour. N. Y. Ent. Soc., XXXV, 331–370, 1927. Coleopterorum Catalogus, Part 95, Junk, Berlin, 1928.

HATCH AND REUTER. Coleoptera of Washington, Silphidæ. Univ. of Wash. Publ. in Biol., 1: 147–162, 1934.

HORN, G. H. Synopsis of the Silphidæ of the U. S. with reference to the genera of other countries. Trans. Am. Ent. Soc., 8: 219–322, pl. V–VII, 1880.

LATREILLE, P. H. Considerations Generales sur l'ordre Naturel des Animaux. Paris, 1810.

LENG, C. W. Catalogue of the Coleoptera of America, North of Mexico and suppl. 1–4. Sherman, Mount Vernon, N. Y., 1920.

SCEGOLEVA-BAROVSHAJA, T. Les Necrophorini (Coleoptera, Silphidæ) de la faune de l'U.R.S.S. Travaux de l'Institut Zool. de l'Academei des sciences de l'U.R.S.S., 1: 161–191, 1932.

SEMENOV-TIAN SHANSKIJ, A. P. De Tribu Necrophorini (Coleoptera, Silphidæ) classification et de ejus distributione geographica. Travaux de l'Inst. Zool. de l'Academie des Science de l'U.R.S.S., 1: 149–160, 1932.

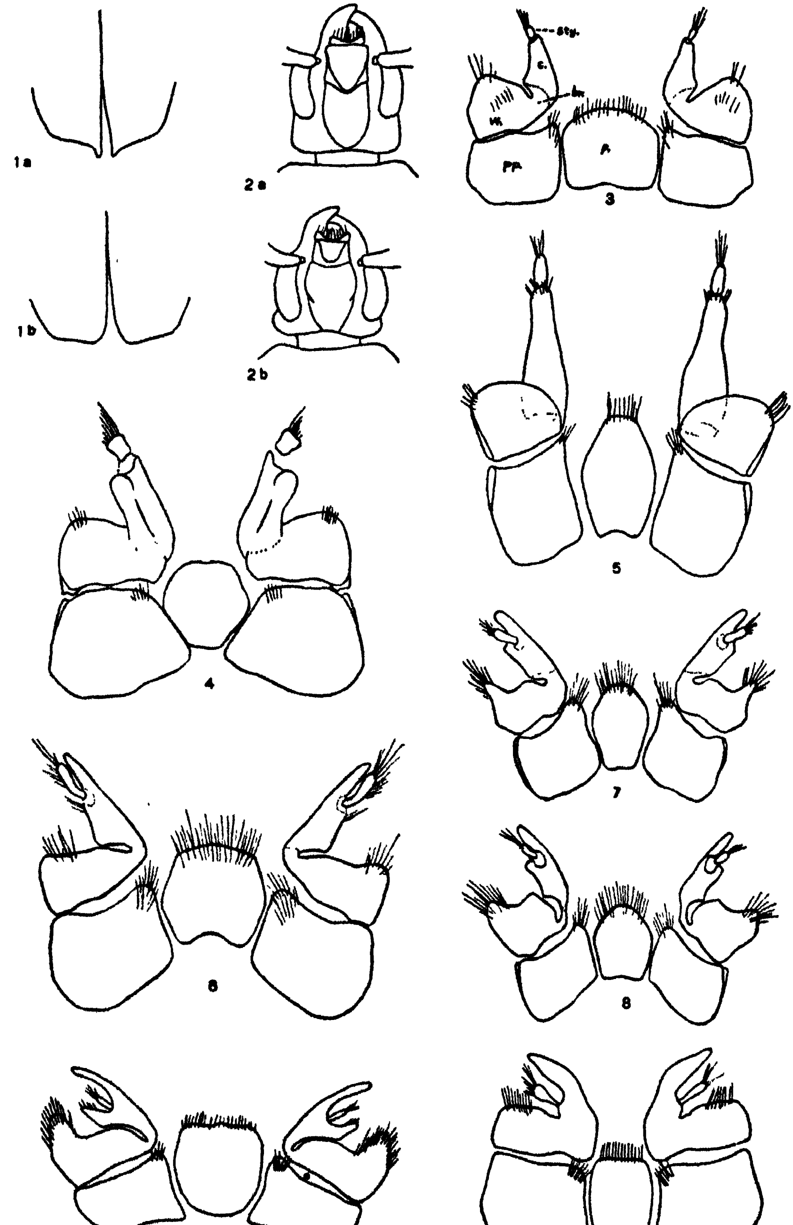
TANNER, V. M. A Preliminary Study of the Genitalia of Female Coleoptera. Trans. Am. Ent. Soc., 53, 5–50, 1927.

ABBREVIATIONS ON PLATES

p.	proctiger	spa.	spatula
pp.	paraprocts	l.	lobe
sty.	stylus	r.	ridge
c.	coxite	br.	bridge
vf.	valvifer	pro.	process
l.g.	lateral guide		

PLATE I

Figure 1a. *Silpha* L. Elytra of female.
Figure 1b. *Silpha* L. Elytra of male.
Figure 2a. *Nicrophorus* Fab. Head of male.
Figure 2b. *Nicrophorus* Fab. Head of female.
Figure 3. *Thanatophilus quadripunctata* L.
Figure 4. *Silpha littoralis* L.
Figure 5. *Silpha discicollis* Brulle.
Figure 6. *Thanatophilus americana* L.
Figure 7. *Thanatophilus novaboracensis* Forst.
Figure 8. *Thanatophilus inæqualis* Fab.
Figure 9. *Blitophaga bituberosa* Lec.
Figure 10. *Thanatophilus trituberculata* Kby.


1a
1b
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2b
sty.
c.
bs.
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PP.
P.
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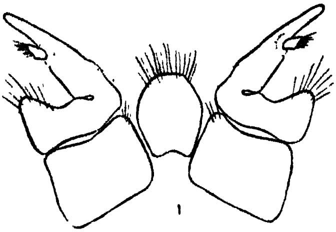
PLATE II

Figure 1. *Thanatophilus ramosa* Say.
Figure 2. *Thanatophilus lapponica* Hbst.
Figure 3. *Thanatophilus coloradensis* Wick.
Figure 4. *Thanatophilus truncata* Say.
Figure 5. *Blitophaga opaca* L.
Figure 6. *Thanatophilus thoracica* L.
Figure 7. *Thanatophilus rugosus* L.
Figure 8. *Nicrophorus carolinus* L.
Figure 9. *Nicrophorus orbicollis* Say.
Figure 10. *Nicrophorus vespilloides* Hbst.



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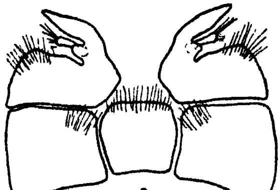

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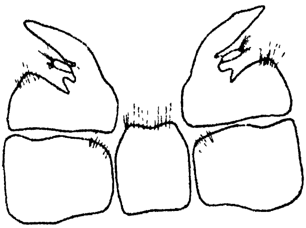

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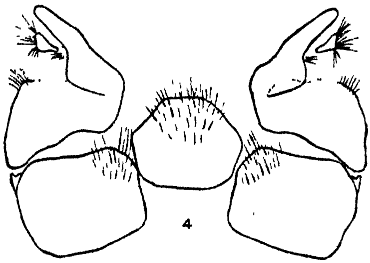

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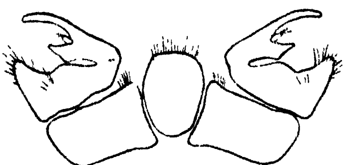

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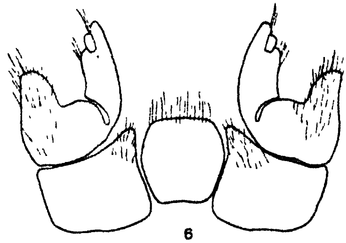

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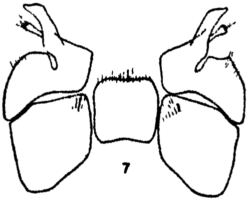

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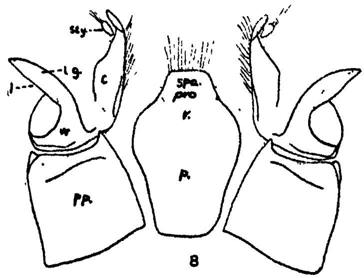

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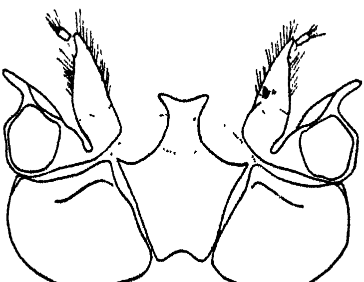

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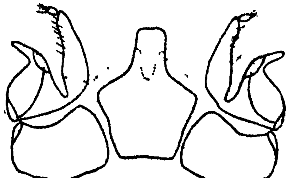

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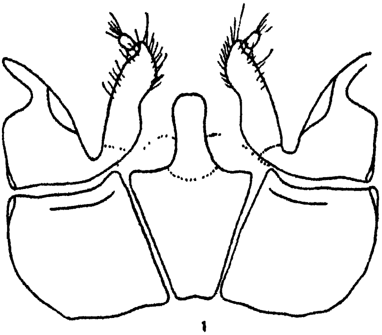
PLATE III

Figure 1. *Nicrophorus americana* Fab.
Figure 2. *Nicrophorus sayi* Fab.
Figure 3. *Nicrophorus nigritus* Mann.
Figure 4. *Nicrophorus pustulatus* Hersch.
Figure 5. *Nicrophorus humator* Fab.
Figure 6. *Nicrophorus germanicus* L.
Figure 7. *Nicrophorus mexicanus* Matth.
Figure 8. *Nicrophorus investigator* Zett.



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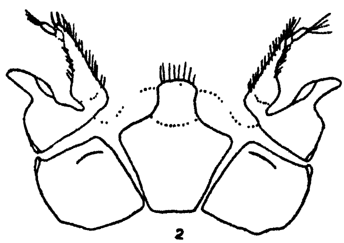

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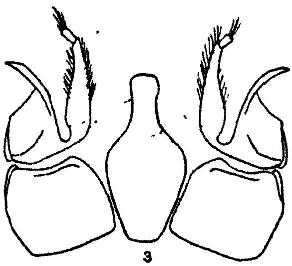

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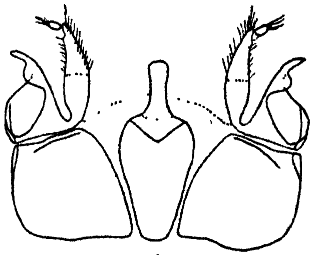

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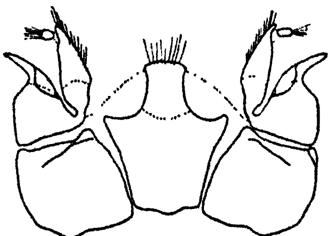

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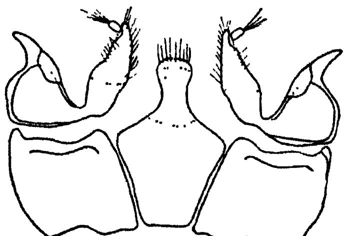

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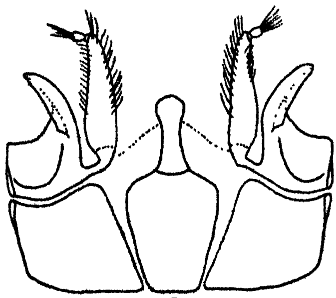

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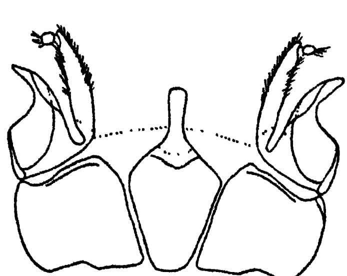

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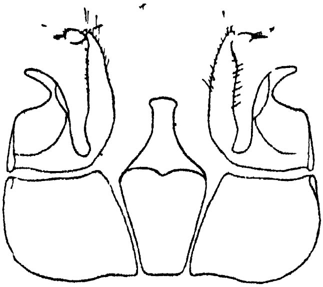
PLATE IV

Figure 1. *Nicrophorus melsheimeri* Kby.
Figure 2. *Nicrophorus tomentosus* Web.
Figure 3. *Nicrophorus vespillo* L.
Figure 4. *Nicrophorus guttula* Mots.
Figure 5. *Nicrophorus obscurus* Kby.
Figure 7. *Nicrophorus hecate* Bland.
Figure 6. *Nicrophorus marginatus* Fab.
Figure 8. *Nicrophorus hybridus* Hatch & Ang.



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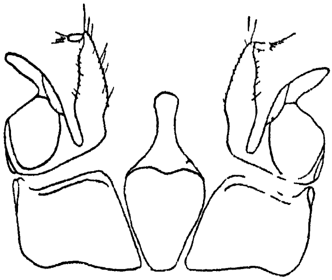

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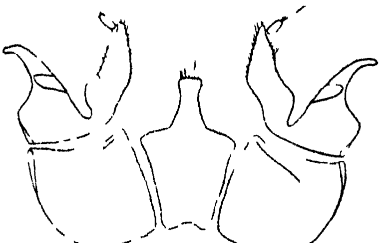

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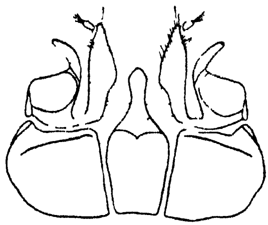

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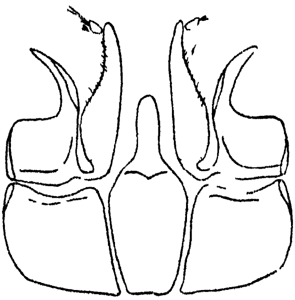

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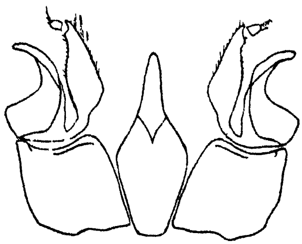

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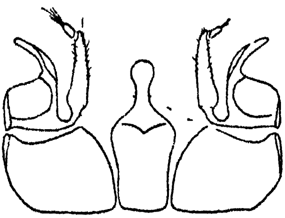

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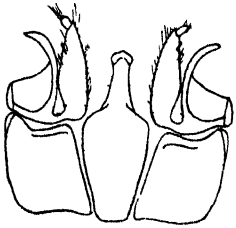


8

GROUP MOTOR RESPONSES OF ADULT AND LARVAL FORMS OF INSECTS TO DIFFERENT WAVE-LENGTHS OF LIGHT

BY HARRY B. WEISS, E. E. MCCOY, JR., AND WILLIAM M. BOYD

This, the fifth paper of a series, relating to the group behavior of insects to colors, is concerned with the responses of seven species of Coleoptera and of sixteen species of lepidopterous, hymenopterous and coleopterous larvæ to ten wave-length bands of light of equal physical intensities, in disarray, from 3650 Å to 7400Å. The tests were run in the sector type equipment described in the third and fourth papers of the series.[1] As outlined in these papers, the insects were placed in an introduction chamber, six feet away from the filter chambers, after the lamps were on and after all filter chambers were open. After the exposure period, the filter chambers, the central compartment, introduction chamber and dark chamber were closed, and counts were then made.

In all previous tests reported upon in the third and fourth papers the color filters were arranged in a sequence beginning with the shorter wave-lengths and extending successively to the longer wave-lengths, as follows: 3650 Å (ultra-violet); 4360 Å (violet-blue); 4640 Å (blue); 4920 Å (blue-blue-green); 5150 Å (blue-green); 5460 Å (yellow-green); 5750 Å (yellow-yellow-green); 6060 Å (yellow-orange); 6420 Å (orange-red); and 7200 Å (infra-red). Each filter chamber was separated from its neighbor by a black chamber.

All tests reported in the present paper, with adults and larvæ, were made with the filters in disarray, as follows: 3650 Å (ultra-violet); 6060 Å (yellow-orange); 4640 Å (blue); 7200 Å (infra-red); 5150 Å (blue-green); 6420 Å (orange-red); 5750 Å (yellow-yellow-green); 4360 Å (violet-blue); 5460 Å (yellow-green); and 4920 Å (blue-blue-green). The wave-length figures represent the peak transmissions of the filters.

[1] JOUR. N. Y. ENT. SOC., 50(1): 1–35, 1942; 51(2): 117–131, 1943.

Owing to the deterioration that occurred in the lamps used in previous tests, new forty-watt, frosted, Westinghouse Mazda lamps and a new General Electric Mazda mercury lamp (type A–H4, 100 watts) were utilized for all tests. The same method, outlined in our first paper,[2] was used for determining the relative positions of the lamps and various filter combinations so that the physical intensities were approximately equal. A slight change in technique, designed to improve the equalization, was recently made and this resulted in a new set of distance settings, differing slightly from those given in the first paper. These new distance settings are shown on page 29.

RESULTS WITH ADULT INSECTS

Table I presents the results of exposing seven species of Coleoptera to ten wave-length bands of light of equal physical intensities, in disarray, in the sector type equipment. By consulting the percentage distribution of those reacting positively to the various wave-length bands and by an examination of the group behavior curves in Figures 1 and 2, it may be noted that the peak response for all species except *Popillia japonica* took place in the ultra-violet (3650–3663 Å) and that secondary peaks occurred either in the blue-blue-green (4920 Å) or in the blue-green (5150 Å). Smaller numbers, in general, appear to have gone to 4360 Å (violet-blue) and larger numbers to 6060 Å (yellow-orange) than in previous tests when the filters were not in disarray. Except for the somewhat reduced attractiveness of 4360 Å and the slightly increased attractiveness of 6060 Å, the behavior patterns, with the filters in disarray, did not differ materially from previous patterns obtained with the filters in orderly array.

Peterson and Haeussler[3] in their work with the Oriental fruit moth and colored lights found that when a less attractive colored light was placed at right angles to a more attractive colored one, more fruit moths went to the less attractive light than when the less attractive one was opposite the more attractive one. There is no doubt that the stimulating power of certain wave-lengths is influenced by their positions with respect to other wave-lengths. But the fact remains that except for the slight differences noted

[2] JOUR. N. Y. ENT. SOC., 49(1): 1–20, 1941.

[3] Ann. Ent. Soc. Amer., 21(3): 353–379, 1928.

DISTANCE SETTINGS FROM 40-WATT LAMPS TO FILTER COMBINATIONS TO OBTAIN EQUAL LIGHT INTENSITY
(115–116 volts)

Filter combinations	Centimeters from lamp tip to filter for various percentages of transmitted light									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
	cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
244–397–555	22.6	24.3	26.1	28.3	30.8	34.8	39.8	47.0	59.6	
243–978½	11.3	12.1	13.3	15.0	17.1	19.8	23.1	27.7	35.6	53.4
245–978	8.3	9.1	10.1	11.1	12.5	14.5	17.5	21.7	28.2	42.8
348–430	2.2	2.8	3.4	4.2	5.2	6.5	8.3	10.6	14.4	24.4
350–430–512	6.2	7.0	7.9	9.0	10.2	11.7	13.9	17.8	23.8	36.4
352–430–502	7.2	8.0	8.9	10.0	11.0	12.7	15.4	19.5	25.7	39.2
338–554	1.6	2.1	2.6	3.4	4.3	5.6	7.3	9.5	12.8	22.4
368–511½	1.2	1.6	2.2	2.8	3.6	4.8	6.4	8.7	11.7	20.8
038–611	0.9	1.3	1.8	2.4	3.2	4.3	5.9	8.0	11.1	19.6
Mercury lamp 738–586	52.0	58.0	62.5	68.0	78.0	86.0	98.0	114.0		

TABLE I

BEHAVIOR OF SEVEN SPECIES OF COLEOPTERA TO TEN WAVE-LENGTH BANDS OF LIGHT, OR COLORS IN DISARRAY

Name and date tested		No. tests	Total no. insects involved	Exposure minutes	Per cent in black chamber	Per cent in introduction chamber	Per cent in center	Per cent reacting to wave-lengths	Distribution of those reacting positively to wave-lengths* 3650 A Per cent	4360 A Per cent	4640 A Per cent	4920 A Per cent	5150 A Per cent	5460 A Per cent	5750 A Per cent	6060 A Per cent	6420 A Per cent	7200 A Per cent
Coleoptera																		
Chrysomelidæ																		
Leptinotarsa decemlineata Say,	5–26–43	3	422	45	1	20	48	31	53	4	0	16	9	9	2	6	1	0
Leptinotarsa decemlineata Say,	5–28–43	4	1,179	50	3	10	46	41	32	6	11	26	11	4	3	6	1	0
Leptinotarsa decemlineata Say,	6– 3–43	6	1,399	15	2	5	32	61	33	5	7	19	17	6	3	7	2	1
Leptinotarsa decemlineata Say,	6– 4–43	4	1,390	15	3	.2	33	62	37	5	6	15	16	7	4	7	2	1
Leptinotarsa decemlineata Say,	6– 7–43	4	1,046	15	4	19	44	33	30	6	7	27	15	6	4	5	0	0
Leptinotarsa decemlineata Say,	6– 8–43	4	1,018	15	5	14	48	33	44	7	7	10	18	4	2	7	1	0
Chrysochus auratus Fab.,	7– 8–43	3	342	15	1	8	28	63	54	8	3	16	12	3	2	2	0	0
Cerambycidæ																		
Tetraopes tetraophthalmus Forst.,	6–21–43	5	579	30	7	15	53	25	34	5	6	26	10	6	3	6	4	0
Lampyridæ																		
Chauliognathus marginatus Fab.,	6–11–43	2	249	15	9	26	48	17	53	0	5	5	14	.7	0	14	2	0
Photuris pennsylvanicus De.G.,	7–12–43	3	545	15	15	37	34	14	32	20	16	6	6	5	4	6	5	0
Scarabæidæ																		
Popillia japonica Newm.,	7– 7–43	3	805	20	7	20	36	37	16	7	6	16	22	12	7	7	6	1
Autoserica castanea Arrow,	7–15–43	3	1,187	30	28	18	25	29	82	2	2	2	5	1	0	4	1	1

* Peak intensities of bands.

above the group behavior patterns for the species tested remained materially unchanged with the filters in disarray. Regardless of the relative positions of the various wave-length bands, the insects made approximately the same selections time after time.

RESULTS WITH LARVAL FORMS

Most of the experimental work on the behavior of insects to colored light has been done with adult insects. Nevertheless there are a few references in the literature to the behavior of larval forms and mention will be made of the photopositive ones.

For example, Mayer and Soule found that the larvæ of *Danais archippus* are photopositive to ultra-violet. Gross,[4] in his study of the reactions of arthropods to monochromatic lights of equal intensities reported that the larvæ of *Zeuzera pyrina,* a lepidopterous wood-borer, and of a noctuid moth *Feltia subgothica,* are photopositive to colors, the order of the effectiveness of stimulation being blue (4200–4800 Å), green (4900–5500 Å), yellow (5700–622 Å), and red (6300–6500 Å). *Lymantria* larvæ, according to Hundertmark[5] appear to prefer blue when different colors are compared. Götz,[6] in his study of the perception of color and form in lepidopterous larvæ found that an appreciation of color occurs in the larvæ of *Vanessa* and *Picris.* These are attracted by the green color of leaves or pieces of paper, regardless of the color of the surroundings, but more so on a white background than on a black one. Lammert[7] reports that caterpillars will go toward a source of light after a blacking of their eyes. And Suffert[8] states that many caterpillars colored like their surroundings and feeding in exposed situations, orient themselves so that the light always falls upon them from a particular angle. These last two instances indicate the possession of a dermal light sense.

Our tests as reported in the present paper involved the exposure of the larvæ of sixteen species of insects to ten wave-length bands of light, of equal physical intensities, from 3600 Å to 7200 Å. These bands were in disarray. From Table II and Figures

[4] Jour. Exp. Zool., 14: 467–512, 1913.

[5] Z. vergl. Physiol., 24: 563–582, 1936.

[6] Z. vergl. Physiol., 23: 429–503, 1936.

[7] Z. vergl. Physiol., 3: 225–278, 1925.

[8] Z. Morph. Oekol. Tiere., 26: 147–316, 1932.

TABLE II

BEHAVIOR OF SIXTEEN SPECIES OF LARVÆ TO TEN WAVE-LENGTH BANDS OF LIGHT, OR COLORS, IN DISARRAY

Name and date tested	No. tests	Total no. insects involved	Exposure minutes	Per cent in black chamber	Per cent in introduction chamber	Per cent in center	Per cent reacting to wave-lengths	Distribution of those reacting positively to wave-lengths* 3650 Å Per cent	4360 Å Per cent	4640 Å Per cent	4920 Å Per cent	5150 Å Per cent	5460 Å Per cent	5750 Å Per cent	6060 Å Per cent	6420 Å Per cent	7200 Å Per cent	Remarks
Coleoptera																		
Chrysomelidæ																		
Leptinotarsa decemlineata Say, 6–9–43	4	1,483	75	2	11	62	25	29	5	8	26	16	5	4	4	3	0	$\frac{1}{2}$ to $\frac{3}{4}$ grown
Hymenoptera																		
Tenthredinidæ																		
Lophyrus lecontei Fitch, 7–13–42	2	466	45	0	7	66	27	46	3	6	6	30	7	0	2	0	0	Full grown
Macremphytus sp., 8–10–43	3	725	40	0	2	30	68	53	1	5	6	21	7	1	6	0	0	Full grown, starved
Lepidoptera																		
Arctiidæ																		
Diacrisia virginica Fab., 6–24–43	3	323	45	5	23	43	29	7	5	3	23	32	9	9	7	4	1	Full grown
Ceratocampidæ																		
Dryocampa rubicunda Fab., 8–23–43	3	237	60	2	11	45	42	24	16	4	9	29	8	3	4	2	1	Full grown
Anisota senatoria A. & S., 9–21–43	4	1,108	30	1	1	33	65	16	8	5	29	16	15	4	4	3	0	$\frac{1}{2}$–$\frac{3}{4}$ grown, starved
Anisota senatoria A. & S., 9–10–43	3	637	40	0	9	71	20	22	4	3	23	16	13	10	5	4	0	$\frac{1}{2}$–$\frac{3}{4}$ grown
Hesperidæ																		
Eudamus tityrus Fab., 9–3–43	3	284	45	3	15	38	44	48	4	1	25	11	9	0	1	1	0	Full grown, starved

* Peak intensities of bands.

TABLE II—(*Continued*)

Name and date tested	No. tests	Total no. insects involved	Exposure minutes	Per cent in black chamber	Per cent in introduction chamber	Per cent in center	Per cent reacting to wave lengths	Distribution of those reacting positively to wave-lengths* 3650 Å Per cent	4360 Å Per cent	4640 Å Per cent	4920 Å Per cent	5150 Å Per cent	5460 Å Per cent	5750 Å Per cent	6060 Å Per cent	6420 Å Per cent	7200 Å Per cent	Remarks
Noctuidæ																		
Hadena turbulenta Hbn., 9–15–43	3	926	30	10	25	37	28	20	3	4	18	22	15	3	11	3	1	¾ grown
Notodontidæ																		
Datana integerrima G. & R., 7–28–43	3	589	45	0	27	41	32	84	0	2	10	1	0	0	3	0	0	¾ grown, starved
Datana integerrima G. & R., 7–30–43	2	402	35	1	1	30	68	56	3	1	11	10	5	3	8	2	1	¾ grown, starved
Datana ministra Dru., 7–13–43	3	699	15	5	7	45	43	63	5	6	4	6	2	1	12	1	0	¾–full grown
Melalopha inclusa Hbn., 9–7–43	2	183	30	32	5	25	38	26	10	4	30	24	3	3	0	0	0	Full grown
Hyparpax aurora A. & S., 9–10–43	3	433	40	3	5	29	63	54	4	3	12	10	7	2	6	1	1	Full grown
Saturnidæ																		
Actias luna Linn., 9–13–43	2	197	50	13	5	50	32	45	16	6	11	6	5	3	6	2	0	¾ grown
Telea polyphemus Cram., 9–13–43	2	215	25	0	3	31	66	22	14	12	13	23	6	2	6	2	0	¾–full grown
Telea polyphemus Cram., 9–14–43	4	165	30	1	3	14	82	29	10	7	12	13	7	7	12	2	1	Full grown, starved
Sphingidæ																		
Ceratomia catalpæ Bdv., 7–2–43	3	387	30	5	5	62	28	50	1	2	9	9	7	5	12	3	2	Full grown
Phlegethontius carolina Linn., 9–13–43	2	61	20	5	15	27	53	20	3	9	28	22	12	0	3	3	0	Full grown

* Peak intensities of bands.

3, 4 and 5 which record their group behavior in percentages and graphically, it is apparent that the peak response for most species took place in the ultra-violet (3650 Å). In nearly all instances a peak either equal to the one in ultra-violet or secondary to it occurred in the blue-blue-green (4900 Å), or in the blue-green (5150 Å). The minor peak at 6060 Å (yellow-orange) is attributed to the disarray of the filters which resulted in this wavelength being next to 3650 Å (ultra-violet).

The larvæ of *Diacrisia virginica* were the only ones which ultraviolet light (3650 Å) failed to stimulate appreciably. These larvæ are found crawling upon the ground or feeding upon low plants. As a whole the group behavior of the larvæ, in general, did not differ from that of numerous adult insects, previously tested, and their color discrimination, so called, was approximately the same as that exhibited by adult insects in spite of the fact that their visual organs are less complex than those of adult insects.

NOTES

Autoserica castanea. This beetle, being nocturnal, was tested at 10:30 P.M.

Hippodamia convergens Guer. The predaceous larvæ of this coccinellid failed to react at all under the conditions of our tests. When placed in the introduction chamber they climbed up the sides and remained there. Apparently their negative geotropic behavior predominated.

Hyphantria cunea Dru. The ½ to ¾ grown larvæ of this species, the fall webworm, made a web in the introduction chamber and stayed there, even though they had been previously deprived of food for twenty hours.

During the course of our work with larvæ it was found that, as a rule, they were more photopositive after having been deprived of food for a half-day or more previous to the tests. The gregariousness of some of the species, especially of the larvæ of *Hadena turbulenta* Hbn., and *Melalopha inclusa* Hbn., appeared to inhibit somewhat their sensitivity to light.

DISCUSSION

In view of the comparative simplicity of the lateral ocelli of larvæ, the similarity of the group behavior of larvæ to that of

adult insects with compound eyes is of considerable interest. Although variable in structure, lateral ocelli in lepidopterous larvæ consist of a group, each ocellus having a structure not unlike the single ommatidium of a compound eye. In the larvæ of sawflies and of many Coleoptera, the ocellus, of which there is only one on each side, is a lens-like, transparent thickening of the cuticle with underlying epidermis, and retinulæ, each made up of two or three visual cells grouped around a rhabdom. These visual cells may be pigmented, or there may be separate pigment cells. Dethier in a recent study[9] of the corneal lens in caterpillars states that "the cornea possesses a short focal distance, great depth of focus, and an extremely low f value permitting the admittance of much light."

Although the king-crab, *Limulus polyphemus,* is not an insect, the work of Hartline and Graham on the nerve impulses and responses of single visual sense cells, to light, in the eye of this animal is of unusual interest and it is within the realm of possibility that a similar process of photoreception may operate in insects.

The lateral facetted eye of the king-crab contains about 300 large ommatidia and the optic nerve fibres come directly from the receptor cells with no intervening neurones. These authors[10] studied the nerve impulses and developed a technique by which was recorded the discharge from a single receptor unit, in the form of oscillograms, representing the potential changes between the cut end and an uninjured portion of the nerve, upon stimulation of the eye by light. The electrical activity in the optic nerve brought about by this stimulation was amplified by a vacuum tube and recorded by an oscillograph. Among other things the stimulation of a single ommatidium resulted in a small strand of the optic nerve showing a regular sequence of nerve impulses. "The discharge in a single fiber begins after a short latent period at a high frequency, which has been found to be as high as 130 per second. The frequency falls rapidly at first, and finally approaches a steady value, which is maintained for the duration of illumination" (Hartline and Graham).

[9] Jour. Cell. and Comp. Physiol., 19(3): 301–313, 1942.

[10] Jour. Cell. and Comp. Physiol., 1(2): 277–295, 1932.

In a later paper[11] these authors studied the responses of single visual sense cells to visible light of different wave-lengths. This was done by means of single fiber preparations from a *Limulus* eye. It was found that when the energy of the stimulating light of different wave-lengths was approximately equal, the response to green was stronger than the responses to either violet or red. When the energy was increased in the red and violet their level of response was raised and when the intensities for the different wave-lengths were adjusted so that the responses were equal, there was no effect of wave-length as such, indicating that single sense cells can gauge brightness but cannot distinguish wave-length. The relative energies of the various wave-lengths required to produce the same response after being adjusted in inverse ratio to the degree to which they are absorbed yielded a visibility curve, for a single visual sense cell, that had its maximum in the green near 5200 Å and that declined symmetrically on each side to low values in the violet near 4400 Å and in the red near 6400 Å. According to the interpretation of visibility curves by Hecht and Williams[12] the stimulation of a single visual sense cell by light depends upon the absorption spectrum of the primary photosensitive substance. The absorption of light by this substance varies with wave-length and the production of a given response needs a certain amount of photochemical change, which in turn requires the absorption of a constant amount of energy.

Hartline and Graham also found that in the same eye of *Limulus* there was a differential sensitivity among optic nerve fibers and their attached sensory cells for different regions of the visible spectrum and they believe that such specialization of the visual cells, coupled with integrated action may give rise to color vision.

In considering the tests with insects reported upon in this and in previous papers,[13] the following patterns of behavior prevailed over and over, when various species were exposed to ten wave-length bands of equal intensities from 3600 Å to 7200 Å. In the composite behavior[14] of 5,454 insects of various orders, mostly

[11] Jour. Gen. Physiol., 18(6): 917–931, 1935.

[12] Jour. Gen. Physiol., 5: 1, 1922.

[13] JOUR. N. Y. ENT. SOC., 49: 1–20, 149–159, 1941; 50: 1–35, 1942; 51: 117–131, 1943.

[14] Ent. News, 54: 152–156, 1943.

coleopterous, the peak response took place at 3650 Å (ultraviolet). From here the response declined gradually to a low point at 4640 Å (blue); then it increased to a secondary peak at 4920 Å (blue-blue-green), and then declined gradually to a low point at 5750 Å (yellow-yellow-green) from which point it levelled off to 6420 Å (orange-red). In the cases of individual species there were deviations from this pattern. *Drosophila* and various species of Coleoptera in some tests responded almost entirely to 3650 Å alone, dropping to a low level at 4360 Å and levelling off at that wave-length. Sometimes the secondary peak occurred at 5150 Å instead of at 4920 Å. Although the peak responses took place at 3650 Å and 4920 Å, small percentages of the test animals went to other wave-lengths. In addition, it was found that when a second test, using the same insects, succeeded the first, the same group behavior pattern took place. The peak response occurred at 3650 Å, the secondary one at 4920 Å. However, the individuals that made up the peaks in the second test were not all the same as those making up the peaks in the first test. In other words, there was a shifting of the individuals that went to the different wave-length bands, but no difference in the final result.

Assuming that the light receptors of insects function in the same way as those of some other invertebrates and considering the results obtained from the single visual sense cells of *Limulus* as outlined by Hartline and Graham and mentioned above, it is possible to venture an explanation for the group behavior pattern of insect response to colors. Starting with the fact that the test insects responded in varying numbers to all wave-lengths from 3650 Å to about 6420 Å, it is apparent that the photosensitive substance of their visual sense cells will function at any of the wave-lengths between 3650 Å and 6420 Å, if the physical intensity of the wave-length is sufficient and constant.

When confronted by ten wave-length bands of equalized intensities which converged upon the insects in the introduction chamber of the apparatus, the primary photosensitive substance of the visual sense cells of a large number absorbed the energy at 3650 Å to a greater extent than the energy at other wave-lengths. This resulted in a photochemical reaction accompanied by physical

changes in nerve fibers, one of which was a change in the electric potential of the point in the fiber that was actively responding measured with respect to a nearby, but as yet, inactive point. This electrical activity in the optic nerve fiber was transmitted to the muscles where changes in tension occurred resulting in the insects going to the ultra-violet (3650 Å) in larger numbers than to any other test wave-length. As the absorption of light by the primary photosensitive substance of the single sense cell varies with wave-length and as the production of a response requires a certain amount of photochemical change plus a constant amount of energy, it seems evident that the energy of the remaining test wave-lengths although equal, was not sufficient to result in a response that equalled that of the ultra-violet. Consequently smaller numbers of individuals responded to the test wave-lengths other than 3650 Å. The question then arises as to why all individuals did not respond to 3650 Å alone. In a group of 100 or more insects collected in the field, it is not expected that they would all be in the same physiological state at the same time. In fact, when tested, only some are photosensitive. Others remain in the introduction chamber, others get as far as the central compartment and others go to the black chamber, all exhibiting different degrees of behavior to light. Among those that are photopositive it is reasonable to assume that there exist some variations by individuals in the sensitivity of their visual receptors. These variations may be connected with different physiological states. They may be due to a depletion of the primary photosensitive substance in the visual sense cells through the action of light, resulting in individuals so affected responding in smaller numbers to wave-lengths other than ultra-violet. Until restorative processes take place in the visual sense cells of such individuals, their sensitivity to ultra-violet declines.

Frequently various species, when tested, responded almost exclusively to ultra-violet. But many others did not. In the case of *Drosophila* which was bred under controlled conditions and which were of uniform ages, the response to ultra-violet was unusually high.

It is realized that these deductions are based upon the behavior of single visual sense cells of the king-crab, to light of different

wave-lengths and no consideration has been given to the fact that individual cellular units act collectively and not independently, nor to the fact that Graham and Hartline[15] found that although the visibility curves for single sense cells in the same eye are approximately identical, they differ by significant amounts. In addition they report that two sense cells were able to distinguish violet from red and taking all these facts into consideration they are of the opinion that such differential sensitivity "may be considered a peripheral mechanism of color vision."

Another reason for the deductions as outlined consists of the behavior of the Japanese beetle, *Popillia japonica,* which was made to respond to what were unattractive wave-lengths under equalized physical intensities, by increasing the intensities of such wave-lengths. In fact with other species as well it was possible to vary the behavior pattern by changing the intensities. And in general, from our work over the past several years, it appears that the behavior patterns of insects to equalized wave-lengths are not unlike the behavior pattern of a single sense cell, in *Limulus,* to equalized wave-lengths. Perhaps the behavior curves in this and in former papers[16] may be interpreted as rough approximations of the absorption spectrum of the photosensitive substance in the combined visual sense cells of many insects, as well as indications of their motor responses to equalized wave-lengths of light.

A word should be said about the comparatively large percentages of test insects which remain in the introduction chamber and central compartment of our testing equipment. We have always attributed this mainly to low illumination. At low illuminations only the most sensitive ommatidia function, there being different thresholds of response for different ommatidia.[17] By others, a falling off in intensity discrimination, due to low illumination is attributed to a nervous coupling of groups of ommatidia to form new units.[18]

[15] Jour. Gen. Physiol., 18: 917–931, 1935.

[16] JOUR. N. Y. ENT. SOC., 49: 1–20, 149–159, 1941; 50: 1–35, 1942; 51: 117–131, 1943.

[17] Hecht and Wald. Jour. Gen. Physiol., 17: 517–547, 1934.

[18] Buddenbrock and Shultz. Zool. Jahrb. Physiol., 52: 513–536, 1933.

The foregoing discussion is an attempt to explain the group behavior patterns, or motor responses of insects to various wavelengths of light of equal physical intensities on the basis of the results obtained by investigators who used single visual sense cells of other invertebrates. It is realized that the motor response to light of a complex organism such as an insect cannot be adequately and definitely explained on the basis of the behavior of single visual sense cells of other animals, nevertheless such work as has been done with single sense cells furnishes valuable clues to the phenomena of vision in insects. Until similar and additional investigations are made on the behavior of photoreceptor cells and optic nerve fibers of insects, singly and in integrated action, one has to be satisfied with implications.

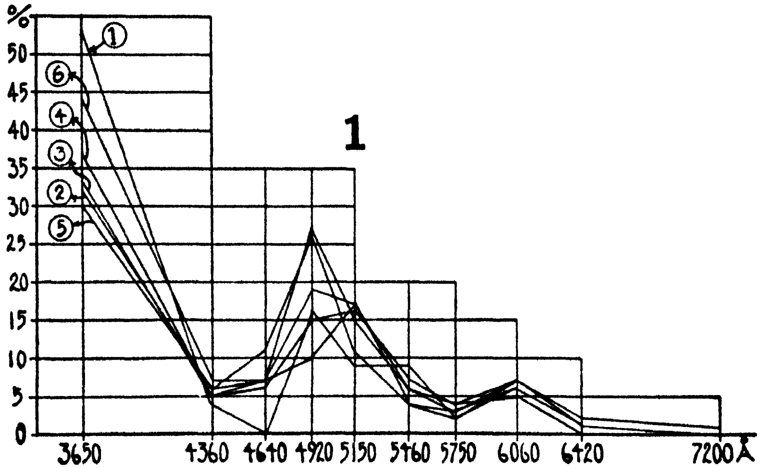
PLATE V

Figure 1. Behavior of six lots of *Leptinotarsa decemlineata* Say, to 10 wavelength bands, in disarray, from 3650 Å to 7200 Å. Physical intensities equalized.

1. 129 beetles. Three tests.
2. 478 beetles. Four tests.
3. 857 beetles. Six tests.
4. 857 beetles. Four tests.
5. 340 beetles. Four tests.
6. 338 beetles. Four tests.

Figure 2. Behavior of six species of Coleoptera to 10 wave length bands, in disarray, from 3650Å to 7200 Å. Physical intensities equalized.

1. *Chrysochus auratus* Say. 217 adults. Three tests.
2. *Tetraopes tetraophthalmus* Forst. 144 adults. Five tests.
3. *Chauliognathus marginatus* Fabr. 42 adults. Two tests.
4. *Photinus pennsylvanica* DeG. 78 adults. Three tests.
5. *Popillia japonica* Newm. 295 adults. Three tests.
6. *Autoserica castanea* Arrow. 338 adults. Three tests.
   Tested after 10: 30 P.M.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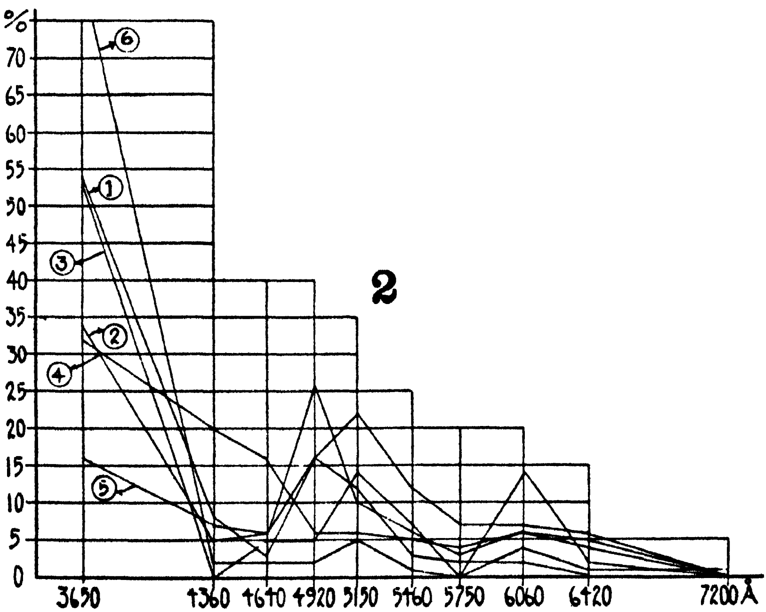
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PLATE VI

Figure 3. Behavior of coleopterous, hymenopterous and lepidopterous larvæ to 10 wave-length bands, in disarray, from 3650 Å to 7200 Å. Physical intensities equalized.

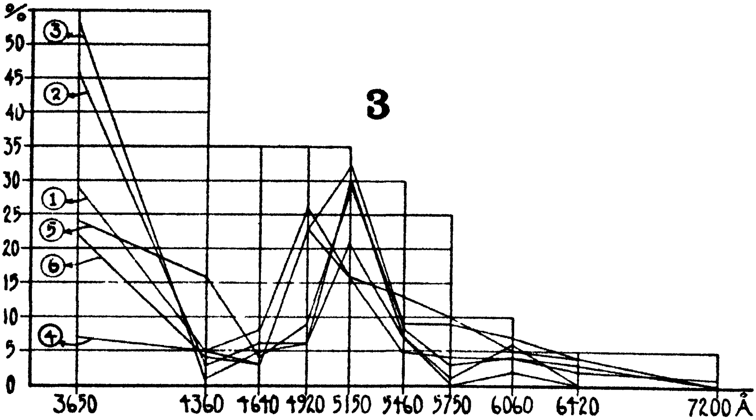
1. *Leptinotarsa decemlineata* Say (Col.). 372 larvæ, ½ to ¾ grown. Four tests.
2. *Lophyrus lecontei* Fitch (Hymen.). 124 larvæ, full grown. Two tests.
3. *Macremphytus* sp. (Hymen.). 491 larvæ, full grown. Three tests. Larvæ starved.
4. *Diacrisia virginica* Fab. (Lep.). 92 larvæ, full grown. Three tests.
5. *Dryocampa rubicunda* Fab (Lep.). 100 larvæ, full grown. Three tests.
6. *Anisota senatoria* A & S (Lep.). 125 larvæ, ½ to ¾ grown. Three tests.

Figure 4. Behavior of lepidopterous larvæ to 10 wave-length bands, in disarray, from 3650 Å to 7200 Å. Physical intensities equalized.

1. *Eudamus tityrus* Fab. 125 larvæ, full grown, starved. Three tests.
2. *Hadena turbulenta* Hbn. 263 larvæ, ¾ grown. Three tests.
3. *Datana integerrima* G. & R. 188 larvæ, ¾ grown, starved. Two tests.
4. *Datana ministra* Dru. 303 larvæ, ¾ to full grown. Three tests.
5. *Melalopha inclusa* Hbn. 70 larvæ, full grown. Two tests.
6. *Hyparpax aurora* S. & A. 274 larvæ, full grown. Three tests.

Figure 5. Behavior of lepidopterous larvæ to 10 wave-length bands, in disarray, from 3650 Å to 7200 Å. Physical intensities equalized.

1. *Actias luna* Linn. 63 larvæ, ¾ grown. Two tests.
2. *Telea polyphemus* Cram. 141 larvae, ¾-full grown. Two tests.
3. *Telea polyphemus* Cram. 136 larvæ, full grown, starved. Four tests.
4. *Ceratomia catalpæ* Bdv. 110 larvæ, full grown. Three tests.
5. *Phlegethontius carolina* Linn. 32 larvæ, full grown. Two tests.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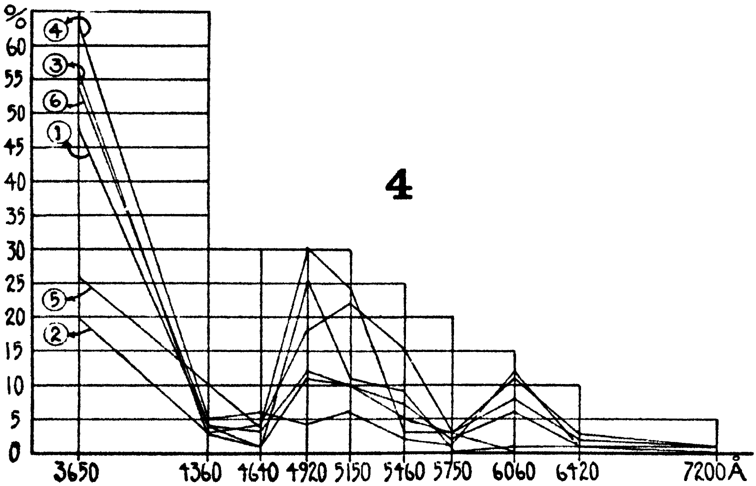
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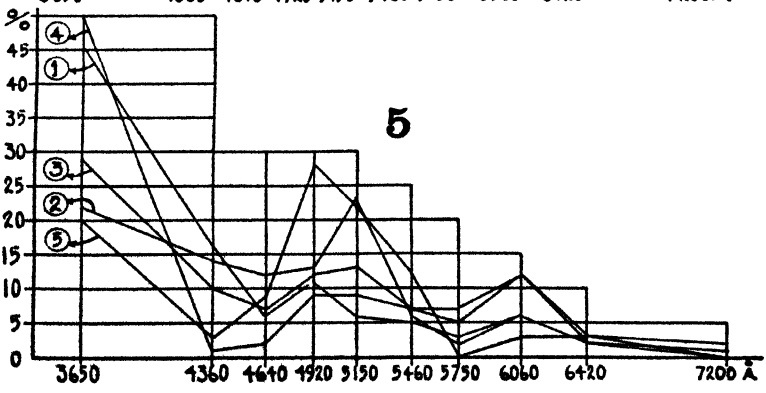
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RECORDS AND DESCRIPTIONS OF NEOTROPICAL CRANE-FLIES (TIPULIDÆ, DIPTERA), XVII

BY CHARLES P. ALEXANDER
AMHERST, MASSACHUSETTS

The previous instalment under this general title was published in September, 1943 (JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY, 51(3): 199–212). The materials here considered are all from Ecuador where they were taken by Mr. William Clarke-Macintyre, Mr. David B. Laddey, and Professor F. Martin Brown. Some of the most interesting of the new species were taken at the station "Zumbi," in the Province of Santiago-Zamora, southern Oriente, by Mr. Laddey. For a brief discussion of this station, the preceding instalment should be consulted. I am greatly indebted to the collectors for the privilege of retaining the types of the novelties in my collection of these flies.

Genus *Gnophomyia* Osten Sacken

Gnophomyia (Gnophomyia) argutula new species.

General coloration of mesonotal præscutum gray with three dark brown stripes, the lateral portions orange-yellow; thoracic pleura variegated dark brown and obscure yellow; knobs of halteres dark brown; femora yellow, the tips conspicuously blackened; wings yellowish gray, with three darker clouds or bands, the second at the level of cord; cell *1st* M_2 widened outwardly, nearly four times as wide at outer end as at base; cell *2nd A* broad; abdominal segments bicolored, the basal portions reddish yellow, the remainder dark brown; male hypopygium with the outer dististyle acute at tip; phallosome unusually broad and obtuse.

MALE.—Length about 7 mm.; wing 7.5 mm.

Rostrum brown; palpi black. Antennæ brownish black; flagellar segments nearly cylindrical; verticils of outer segments much longer and more conspicuous than those of the basal segments. Anterior vertex dull orange, relatively narrow, the eyes correspondingly large and protuberant; posterior portion of head brownish gray, the anterior orbits obscure orange.

Pronotum obscure brownish yellow above, dark brown on sides; pretergites obscure yellow. Mesonotal præscutum with the ground color of interspaces gray, with three entire dark brown stripes, the median one more reddened at cephalic end; humeral and lateral portions of sclerite obscure orange yellow; posterior sclerites of notum dark brown, sparsely pruinose; scutellum paler,

with a central, dark brown spot; dorsal pleurotergite obscure yellow. Pleura chiefly dark brown, sparsely pruinose, restrictedly but conspicuously variegated with obscure yellow, distributed as follows: Dorsal portion of sternopleurite; posterior border of pteropleurite, and meral region. Halteres short, stem yellow at base, the remainder dark brown. Legs with the coxæ brown, sparsely pruinose; trochanters obscure yellow; femora yellow, the tips rather broadly and conspicuously blackened; tibiæ and tarsi yellow, only the terminal segment weakly darkened. Wings with the ground color yellowish gray, the color greatly restricted by three more or less distinct, slightly darker clouds or bands, the most conspicuous at the cord and over outer end of cell *1st* M_2; slightly less distinct bands at proximal fourth of wing and as a nearly apical darkening in the cells beyond cord; stigma very long and narrow, dark brown; veins yellow in the ground areas, brown in the darkened fields. Venation: Sc_1 ending about opposite the short transverse R_2; *Rs* in longitudinal alignment with R_5, *r-m* at its fork; cell *1st* M_2 strongly widened outwardly, nearly four times as wide at outer end as at base; cell *1st* M_2 approximately as long as vein M_4 beyond it; cell *2nd A* noticeably shorter and broader than in *duplex*.

Basal abdominal segments bicolored, dark brown, the basal rings conspicuously reddish or reddish yellow, the subterminal segments more uniform dark brown; hypopygium and preceding segment more yellowish; sternal pattern generally like the tergal. Male hypopygium with the outer dististyle much less conspicuously flattened than in *laticincta*, its apex acute; base of style with only two elongate setæ. Inner dististyle about one-half as long as the outer style, provided with numerous setæ, including about three of unusual length. Phallosome unusually broad and obtuse.

Holotype, ♂, Zumbi, Rio Zamora, Santiago-Zamora, altitude 700 meters, November 1, 1941 (Laddey).

The nearest relatives are *Gnophomyia* (*Gnophomyia*) *duplex* Alexander and *G.* (*G.*) *laticincta* Alexander, which have the legs and wings somewhat similarly patterned. The former species is still known only from the female sex, differing from the present fly in the venation and in the details of coloration of body and wings. The latter species, *laticincta*, differs conspicuously in the structure of the male hypopygium, especially of the outer dististyle.

Gnophomyia (Gnophomyia) bulbibasis new species.

General coloration of mesonotum dark brown, very sparsely pruinose, on præscutum forming a discal shield; thoracic pleura striped longitudinally with dark brown and reddish; halteres darkened; legs pale brown; wings grayish subhyaline, stigma scarcely differentiated; male hypopygium with the outer dististyle conspicuously bulbous just beyond base; gonapophyses appearing as blackened spines.

MALE.—Length about 4.5–5.5 mm.; wing 5–6.2 mm.

FEMALE.—Length about 5 mm.; wing 5.5 mm.

Rostrum and palpi dark brown. Antennæ dark brown; basal flagellar segments subcylindrical, the outer ones shorter; verticils subequal in length to the segments. Head dark gray; eyes large; anterior vertex only a little wider than the diameter of scape.

Pronotum above yellow, darker on sides. Mesonotum almost uniformly dark brown, very sparsely pruinose, on præscutum forming a discal shield that leaves the humeral and lateral portions yellowish, in cases more obscure than in others. Pleura reddish, with a conspicuous dark brown dorsal stripe extending from the propleura to the postnotum, passing above the halteres; dorsopleural region yellow, confluent with the similarly colored lateral præscutal borders; immediately ventrad of the dark pleural stripe a more or less distinct paler longitudinal line extending from behind the fore coxæ to the base of abdomen. Halteres dusky, the knob still darker. Legs with coxæ obscure yellow to testaceous yellow; trochanters yellow; remainder of legs pale brown, the femoral bases clearer yellow; outer tarsal segments passing into darker brown. Wings grayish subhyaline, the extreme base yellow; stigmal area very restricted and pale, scarcely differentiated; veins pale brown, yellow in the prearcular field. Venation: *Sc* long, Sc_1 ending just before level of R_2, Sc_2 some distance from its tip, lying opposite or before the fork of *Rs*; *r-m* before or close to fork of *Rs*; *m-cu* about three-fourths its own length beyond the fork of *M*.

Abdominal tergites brownish black, the sternites a trifle more piceous; hypopygium yellowish brown. Ovipositor with cerci relatively short and stout, with setæ to the tips of the valves. Male hypopygium with the outer dististyle conspicuously expanded or bulbous just beyond base, thence narrowed to a long straight rod that terminates in an acute point. Inner dististyle much shorter, obtuse at tip; at base with about four powerful setæ, with other shorter setæ on distal half, chiefly near apex. Gonapophyses appearing as blackened spines.

Holotype, ♂, Zumbi, Rio Zamora, Santiago-Zamora, altitude 700 meters, November 4, 1941 (Laddey). Allotopotype, ♀, with the type. Paratopotypes, 2 ♂♂, 1 ♀, October 31–November 2, 1941 (Laddey).

Gnophomyia (*Gnophomyia*) *bulbibasis* has the structure of the male hypopygium, especially of the gonàpophyses, somewhat as in *G.* (*G.*) *oxymera* Alexander, from which it differs in other hypopygial characters, as the bulbous basal enlargement of the outer dististyle.

Gnophomyia (Gnophomyia) fessa new species.

General coloration of mesonotum and the dorsal pleurites dark brown, ventral pleurites reddish brown; rostrum, antennæ and halteres black; femora

obscure yellow, with a narrow subterminal darker ring; wings subhyaline, stigma reduced to a narrow seam; male hypopygium with the inner dististyle bulbous, the apex conspicuously wider than the base; gonapophyses incurved, appearing as separate blades, blackened and microscopically serrulate at bases.

MALE.—Length about 5 mm.; wing 5 mm.; antenna about 1.5 mm.

FEMALE.—Length about 6.5 mm.; wing 6 mm.

Rostrum and palpi brownish black. Antennæ black throughout; basal flagellar segments subcylindrical, the outer ones more elongate-oval, with verticils that exceed the segments in length. Head dark gray; eyes (male) relatively large, the anterior vertex correspondingly narrowed.

Pronotum brown, the pretergites conspicuously light yellow. Mesonotum almost uniform dark brown, the surface very sparsely pruinose, the central portion of præscutum and the scutal lobes slightly darker. Pleurotergite and dorsal pleura dark brown, contrasting abruptly with the reddish brown ventral pleurites, the surface sparsely pruinose. Halteres brownish black throughout. Legs with coxæ reddish; trochanters yellow; femora obscure yellow, more infuscated immediately before their tips to form a narrow, nearly terminal ring; tibiæ and basitarsi obscure yellow, the tips narrowly infuscated; outer tarsal segments passing into brownish black. Wings subhyaline, with a very faint darker tinge; stigma darker brown but reduced to a linear area adjoining veins R_1 and R_{1+2}, scarcely involving the surrounding membrane; prearcular and costal fields a trifle more yellowish; veins brown, somewhat more brightened in the basal areas. Venation: Sc_1 ending opposite R_2; Rs straight, oblique; basal section of R_5 lacking, r-m at fork of Rs; R_2 variable in position, before the fork of R_{2+3+4} or nearly its own length beyond this fork; cell *1st* M_2 narrow, subequal in length to vein M_4 beyond it; m-cu from one-third to two-thirds its length beyond the fork of M.

Abdominal tergites and hypopygium brownish black; sternites yellow. Ovipositor with cerci relatively small, only weakly sclerotized, with setæ virtually to their tips. Male hypopygium with the outer dististyle a simple, curved, relatively narrow, blackened rod, the tip subacute. Inner dististyle relatively short, bulbous, the apex almost twice as wide as the base, with several setæ, chiefly on the distal third. Phallosome with the gonapophyses incurved, appearing as separate blades, at apex blackened and microscopically roughened to serrulate; apex of phallosome narrow.

Holotype, ♂, Palmar, Rio Maizito, Manabi, altitude 200 meters, May 20, 1941 (Laddey). Allotopotype, ♀, pinned with type.

Gnophomyia (*Gnophomyia*) *fessa* is most similar to species such as *G.* (*G.*) *oxymera* Alexander and *G.* (*G.*) *nectarea* new species, differing in the details of coloration and, especially, the structure of the male hypopygium, as the inner dististyle and the phallosome.

Gnophomyia (Gnophomyia) nectarea new species.

Size small (wing, male, about 5 mm.); mesonotum and dorsal pleura opaque black, the ventral pleurites abruptly reddish; halteres dusky; legs brownish yellow; wings subhyaline, the stigma and an extensive cloud on proximal third of wing infuscated; vein R_2 very faint to nearly atrophied; cell *1st* M_2 long and narrow; cell *2nd A* relatively narrow; male hypopygium with the outer dististyle slender; inner dististyle with a conspicuous basal lobe that is microscopically corrugated or wrinkled.

MALE.—Length about 4–4.8 mm.; wing 4.5–5.5 mm.; antenna about 1.3–1.6 mm.

FEMALE.—Length about 5 mm.; wing 5 mm.

Rostrum dark brown; palpi black. Antennæ of moderate length, dark brown; flagellar segments subcylindrical; longest verticils subequal in length to the segments. Head brown, the orbits and posterior vertex light gray; anterior vertex relatively narrow, about one-third the diameter of scape; eyes (male) correspondingly large.

Pronotum dark brown; pretergites light yellow. Mesonotum chiefly blackened, the surface opaque by a sparse pruinosity; central portion of scutum and posterior border of scutellum slightly more reddened. Dorsal pleurites covered by a broad black longitudinal stripe, this area also involving the pleurotergite and surrounding the root of halteres; ventral pleurites reddish, very sparsely pruinose. Halteres dusky, base of stem restrictedly brightened. Legs with coxæ and trochanters yellow; remainder of legs brownish yellow, the outer tarsal segments more infuscated. Wings subhyaline, the extreme base restrictedly yellow; stigma oval, darker brown; a conspicuous dusky cloud or wash on basal third of wing in general vicinity of vein *Cu*, involving the bases of cells *Cu*, *1st A* and *2nd A*, together with much of *M*; veins brown, yellow in the flavous basal region. Venation: Vein R_2 very faint to nearly atrophied; *Rs* in direct longitudinal alignment with R_5; branches of *Rs* all extending generally parallel to one another; cell *1st* M_2 relatively long and narrow, its inner end pointed or strongly narrowed, the outer end more widened, the cell subequal in length to vein M_4; *m-cu* less than its own length beyond fork of *M*, at near one-fourth to one-fifth the length of the cell; cell *2nd A* relatively narrow.

Abdominal tergites and the hypopygium brownish black; basal sternites a trifle paler. Male hypopygium with the outer dististyle unusually slender throughout, narrowed at apex to a subacute point. Inner style with a conspicuous basal lobe or shoulder, its surface and adjoining margin of style microscopically wrinkled. Phallosome of moderate width, its tip blackened and slightly narrowed to an obtuse point, the surface microscopically wrinkled.

Holotype, ♂, Zumbi, Rio Zamora, Santiago-Zamora, altitude 700 meters, November 2, 1941 (Laddey). Allotopotype, ♀. Paratopotypes, 2 ♂♂, October 30–November 5, 1941 (Laddey).

Gnophomyia (*Gnophomyia*) *nectarea* is entirely distinct from other small-sized regional members of the genus. From all such, it differs conspicuously in the peculiar wing pattern and in the structure of the male hypopygium.

Gnophomyia (Gnophomyia) tuber new species.

General coloration of mesonotum medium brown, with poorly defined pattern; pleura with a broad, medium brown, longitudinal stripe over the dorsal sclerites; halteres yellow; wings with a buffy tinge, brighter in the basal portions; abdominal tergites reddish brown, weakly darkened laterally; male hypopygium with the basistyles short, on mesal face near base with a conspicuous darkened tubercle, this provided with about three conspicuous setæ; outer dististyle compressed-flattened, its apex obtuse; inner dististyle with the apex very obtuse to subtruncate.

MALE.—Length about 6–6.3 mm.; wing 6.8–7 mm.; antenna about 1.5–1.6 mm.

Rostrum testaceous brown; palpi brownish black. Antennæ with the scape and pedicel brownish yellow, flagellum brownish black; flagellar segments long-cylindrical, the terminal segments shorter; verticils considerably exceeding the segments in length. Head brownish gray; anterior vertex relatively narrow, eyes large.

Pronotum light yellow above, darker on sides; pretergites light yellow. Mesonotal præscutum medium brown, sparsely pruinose, the median area more darkened, behind forming more or less distinct stripes; scutal lobes similarly darkened, the posterior border obscure yellow; scutellum brown, with a yellow spot on either side of base; postnotum medium brown, more yellowish on suture between mediotergite and pleurotergite. Pleura with a broad but relatively inconspicuous, medium brown stripe, more intense in front, becoming diffuse behind; dorsopleural region yellow; ventral pleurites obscure yellow, paler yellow behind. Halteres yellow. Legs with the coxæ and trochanters yellow; femora obscure yellow, weakly darkened at or near tips; tibiæ and basitarsi yellow, the tips narrowly and inconspicuously infuscated; outer tarsal segments brownish black. Wings relatively broad, with a sandy or buffy tinge, the prearcular and costal fields clearer yellow; stigma very restricted in area, pale brown; veins brown, more brownish yellow in the brightened portions. Venation: Sc_1 ending about opposite the fork of R_{2+3+4}, Sc_2 nearly opposite the fork of *Rs*; R_{2+3} more than one-third R_{2+3+4}; *Rs* in direct longitudinal alignment with R_5; *r-m* beyond fork of *Rs*; cell *1st* M_2 relatively long, subequal to vein M_4 beyond it; *m-cu* about two-thirds its length beyond fork of *M*.

Abdominal tergites reddish brown, weakly darkened laterally; sternites clearer yellow; hypopygium yellowish brown. Male hypopygium with the basistyles short, on mesal face near base with a conspicuous darkened tubercle, this provided with about three conspicuous setæ. Outer dististyle darkened, conspicuously compressed-flattened, widest at near midlength, its apex

obtuse. Inner dististyle extending about to midlength of the outer style, dark-colored, its apex very obtuse to subtruncate; rather numerous setæ, including a row of four or five larger ones along the lower or cephalic margin. Phallosome relatively broad, the apex obtuse.

Holotype, ♂, Playas de Montalvo, Los Rios, altitude 15 meters, March 5, 1938 (Macintyre). Paratopotypes, 1 ♂, 1 sex ?, pinned with type.

In its general appearance and wing coloration, the present fly is most like *Gnophomyia* (*Gnophomyia*) *acricula* Alexander and *G.* (*G.*) *digitiformis* Alexander, but has a very different hypopygium. The tubercle on the basistyle is not found in any other species known to me.

Genus *Neognophomyia* Alexander

Neognophomyia spectralis new species.

General coloration of mesonotal præscutum reddish yellow, the posterior sclerites darker; vertex yellow, with a brown central area; thoracic pleura with a conspicuous dorsal black stripe; tips of femora, tibiæ and basitarsi broadly blackened; wings with a pale yellow tinge, patterned with brown, including a subbasal fascia; abdominal tergites conspicuously patterned with brownish black and yellow; male hypopygium with the tergal spines blackened, nearly straight; phallosome produced at apex into lateral horns.

MALE.—Length about 5–5.5 mm.; wing 6–7 mm.

Rostrum obscure yellow; palpi brown. Antennæ with scape and pedicel dark brown; basal flagellar segments pale brown, the outer ones paling to brownish yellow; flagellar segments passing from oval through long-oval; verticils conspicuous. Head yellow, the anterior vertex with a conspicuous brown area; anterior vertex moderately wide, a little more than twice the diameter of the scape.

Pronotum yellow medially, brownish black on sides. Mesonotal præscutum reddish yellow, more yellowish on lateral and humeral portions, in cases more darkened, especially near suture; scutum yellow, each lobe with two brown areas; scutellum black, more or less pruinose; postnotum brownish black, including both the mediotergite and pleurotergite. Pleura reddish yellow with a broad black longitudinal stripe beginning on sides of pronotum, involving the anepisternum, dorsal pteropleurite and the postnotum, as described. Halteres yellow. Legs with the coxæ yellow to reddish yellow; trochanters yellow; femora, tibiæ and basitarsi yellow, with broad and conspicuous black tips; remainder of tarsi black. Wings with a pale yellow tinge, patterned with brown, including a broad seam from stigma across anterior cord, and narrower seams on *m-cu* and outer end of cell *1st* M_2; a less conspicuous subbasal band from origin of *Rs* extending obliquely across cell *M* into cells *Cu*, *1st A* and *2nd A*; extreme base of wing blackened; veins

yellow to brownish yellow, darker brown in the patterned areas. Venation: R_2 at near midlength of petiole of cell R_3; cell *1st* M_2 strongly narrowed at proximal end; *m-cu* from about one-half to approximately its own length beyond the fork of *M*.

Abdominal tergites yellow, handsomely patterned with brownish black, the segments chiefly darkened with a large yellow area at posterior border of each segment, encroaching on the base of the succeeding segment, the outer segments more uniformly darkened, greatly restricting the yellow color; sternites yellow, the terminal segments more darkened; hypopygium chiefly obscure brownish yellow. Male hypopygium with the tergal spines appearing as long, nearly straight, blackened blades, a little expanded at base, thence gradually narrowed to the acute tips. Outer dististyle relatively slender; outer margin of distal third with five long setæ, additional to the single terminal bristle. Inner dististyle large and massive, terminating in a broad blackened beak, the apical border with about seven or eight strong setæ; basal tooth or flange of style strongly blackened, provided with four strong setæ. Phallosome relatively wide, at apex produced into a slender spinous point that is directed laterad, immediately cephalad of which is a broadly rounded emargination.

Holotype, ♂, Baños, Tungurahua, altitude 2,000 meters, July 14, 1939 (Macintyre). Paratopotypes, 7 ♂♂, altitude 1,700–2,000 meters, May 11–June 2, 1937; paratype, 2 ♂♂, Pititi, near Baños, altitude 1,900 meters, June 14, 1937 (Macintyre).

The only generally similar species is *Neognophomyia hirsuta* (Alexander) of eastern Brazil, which has the pattern of the body, legs and wings somewhat the same but with the male hypopygium entirely different. This latter species has the subbasal darkened wing band much wider and more continuous than in the present fly.

Neognophomyia interrupta new species.

Allied to *hostica;* general coloration yellow, the præscutum with the disk chiefly reddish yellow; wings grayish yellow, with a narrow brown seam along cord; abdomen pale, with tergites three, five and six conspicuously dark brown; male hypopygium with the outer dististyle strongly constricted at near midlength, the bulbous outer portion terminating in two subequal elongate setæ; tergal spines pale, angularly bent beyond midlength.

MALE.—Length about 4.5 mm.; wing 5 mm.

Rostrum pale yellow; palpi pale, the outer segments darkened. Antennæ with scape and pedicel light yellow; flagellum broken. Head obscure brownish yellow; eyes (male) relatively large.

Pronotum yellow. Mesonotal præscutum yellow, with three more or less confluent more reddish stripes that form a nearly continuous discal area;

scutal lobes brownish black, the remainder of scutum more brownish yellow; scutellum and mediotergite brownish yellow, the pleurotergite almost covered by an oval velvety black spot, as is common in the genus. Pleura reddish yellow the anepisternum a little infuscated. Halteres uniformly pale yellow. Legs with the coxæ and trochanters yellow; remainder of legs broken. Wings grayish yellow, the prearcular and costal fields somewhat brighter yellow; a narrow but conspicuous brown seam along cord, becoming indistinct or obliterated at fork of *M*; veins brownish yellow, darker in the infuscated areas. Venation: R_2 at about one-third the length of petiole of cell R_3; vein R_3 oblique; cell *1st* M_2 only slightly widened outwardly; *m-cu* at near one-third the length of the cell.

Abdomen conspicuously patterned; basal tergites brownish yellow, darkened laterally; tergites three, five and six conspicuously dark brown; tergites four, seven and eight pale; hypopygium and sternites more uniformly yellow. Male hypopygium with the outer dististyle strongly constricted at near midlength, the base widened, the apex bulbous, its extreme tip broadly obtuse with two subequal elongate setæ. In *hostica,* the style is unusually slender, gradually narrowed beyond the basal enlargement, the tip unusually slender and thus with only a single apical seta. Inner dististyle much as in *hostica,* more widened at near midlength, the setæ at this point slightly more numerous, longer and paler. Phallosome narrower. Tergal spines somewhat as in *hostica,* the basal section shorter.

Holotype, ♂, Zumbi, Rio Zamora, Santiago-Zamora, altitude 700 meters, November 5, 1941 (Laddey).

The most similar described species is *Neognophomyia hostica* Alexander, of Peru, which differs most evidently in the coloration of the abdomen and in the structure of the male hypopygium, as compared above.

Genus *Gonomyia* Meigen

Gonomyia (Progonomyia) acrissima new species.

General coloration gray, the præscutum with three conspicuous brown stripes; thoracic pleura dark gray with a broad yellow longitudinal stripe; legs dark brown, the tarsi black; wings with a weak grayish tinge, unpatterned except for the very pale brown and inconspicuous stigma; male hypopygium with the mesal face of basistyle before apex with a longitudinal group of acute spines, these exceeding 60 in number.

MALE.—Length 5.5–5.6 mm.; wing 6–6.2 mm.; antenna about 1–1.1 mm. Rostrum black, sparsely pruinose; palpi brownish black. Antennæ with the scape dark brown, pedicel and flagellum black; flagellar segments subcylindrical to long-oval with verticels that are subequal in length to the segments. Head gray; vertex with a median brown line.

Pronotum blackened, pruinose, the lateral portions, together with the anterior pretergites, obscure yellow. Mesonotal præscutum gray, with three

conspicuous brown stripes, the median one not reaching the suture, the laterals crossing the suture onto the scutal lobes; pseudosutural foveæ black, conspicuous; posterior sclerites of notum gray, the posterior border of scutellum more obscure yellow; postnotum gray, the dorsal portion of pleurotergite and adjoining portion of mediotergite obscure yellow. Pleura dark gray, with a broad and conspicuous yellow stripe extending from behind the fore coxæ across the dorsal sternopleurite, behind including the ventral pteropleurite, meron and metapleura. Halteres with stem yellowish brown, knob darker brown. Legs with coxæ light brown, sparsely pruinose; trochanters brownish yellow; remainder of legs dark brown, the tarsi passing into black. Wings with a weak grayish tinge, unpatterned except for the very pale brown stigma; extreme wing base paler; veins brown, brightened at base of wing. Venation: *Sc* relatively short, Sc_1 ending a distance beyond origin of *Rs* about equal to *m-cu*, Sc_2 a slightly shorter distance before origin; R_2 indicated by a very faint element at midlength of stigma; cell *2nd* M_2 nearly twice its petiole; *m-cu* from three-fifths to two-thirds its length before the fork of *M*.

Abdominal tergites dark grayish brown, sternites slightly paler; eighth and ninth segments somewhat paler brown, the styli darker. Male hypopygium with the apex of basistyle obtuse, unarmed; mesal face immediately back from tip with an extensive longitudinal area of acute spines, these totalling in excess of 60. Outer dististyle a semicylindrical blade, its apex narrowed into an acute black spine. Intermediate style a long darkened blade, about one-half longer than the outer style; at near one-third its length bearing a more slender branch or arm that is approximately one-half as long as the main apical branch; stem near the branch with numerous setæ, these becoming even longer and more conspicuous on base of lateral branch; main or axial branch glabrous, gradually narrowed to the subacute cultriform apex. Inner dististyle broad, obtuse at apex, near margin provided with several setæ, those at and near apex longest. Ædeagus relatively slender, narrowed outwardly, near apex with small and inconspicuous lateral shoulders.

Holotype, ♂, Baños, Tungurahua, altitude 1,450 meters, April 23, 1939 (Macintyre). Paratopotype, 1 ♂.

The present fly is readily distinguished from all other generally similar forms by the structure of the male hypopygium, especially the spinous area near apex of basistyle. Such armature is uncommon in the subgenus and in all other cases the number, arrangement and shape of the spines is different; in *Gonomyia* (*Progonomyia*) *compacta* Alexander there is a relatively large group of spiculose points; in *G.* (*P.*) *serena* Alexander, the spines of the general type of the present fly but very few in number; in *G.* (*P.*) *thiosema* Alexander, an even larger group of elongate spinous pegs on mesal face of basistyle but

these with obtusely rounded tips. In all these species, the structure of the diststyles is likewise distinctive.

Gonomyia (Progonomyia) hyperplatys new species.

General coloration of notum grayish brown; antennæ black throughout; pleura blackened, sparsely pruinose, with a conspicuous yellow longitudinal stripe; knobs of halteres darkened; wings yellowish, restrictedly patterned with pale brown; Sc_1 ending shortly beyond origin of *Rs*; male hypopygium with the phallosome unusually wide, appearing as a broadly flattened plate, each outer lateral angle further produced.

MALE.—Length about 6 mm.; wing 6.6 mm.

Rostrum and palpi dark brown. Antennæ brownish black throughout; flagellar segments subcylindrical, passing into long-oval, with verticils that exceed the segments. Head brownish gray on anterior vertex, deepening in color behind the antennal bases, the broad posterior vertex clear gray.

Pronotum obscure yellow medially, dark brown sublaterally; pretergites yellow. Mesonotum dark grayish brown, the humeral and lateral portions light yellow; scutellum more reddish brown; mediotergite dark brown, with a conspicuous yellow area on either side of basal half; dorsal portion of pleurotergite similarly yellow. Pleura blackened, sparsely pruinose, with a conspicuous yellow longitudinal stripe extending from above the fore coxæ across the dorsal sternopleurite to the ventral pteropleurite and meral region. Halteres with stem yellow, knob weakly darkened. Legs with the coxæ basally dark brownish gray, the tips restrictedly yellow; trochanters brown; remainder of legs broken. Wings with a yellowish tinge, restrictedly patterned with rather pale brown, the areas chiefly restricted to the vicinity of the veins, distributed as follows: Origin of *Rs*; stigma; cord and base of cell *2nd* M_2; two small isolated spots in Anal cells, one near outer end of cell *1st A* adjoining vein *2nd A*, the other near center of cell *2nd A*; veins brown. Venation: *Sc* short, Sc_1 ending shortly beyond origin of *Rs*, Sc_2 about an equal distance before this origin, *Rs* relatively long, square and spurred at origin; R_2 about twice R_{3+4}; *m-cu* from about one-third to one-half its length before fork of *M*.

Abdomen brownish black; ninth segment abruptly yellow, the styli again blackened. Male hypopygium with the outer diststyle a short, slender, curved rod that narrows to the acute blackened tip, the outer margin with delicate microscopic setulæ. Intermediate style broadly flattened, entirely dark-colored, the inner margin at near midlength produced into a sharp spine, the surface basad of this with conspicuous setæ; apical portion of style appearing as a broad flattened basal flange that narrows into a long arm that is narrowly but deeply notched at apex. Inner diststyle a dusky lobe with strong spinous setæ along the entire inner face, the terminal one longest. Phallosome unusually wide for a member of this subgenus, appearing as a broadly flattened plate subtending the ædeagus, each outer lateral angle produced further into a flattened lobe or blade, with about seven setæ chiefly distributed along the outer margin near apex.

Holotype, ♂, Baños, Tungurahua, altitude 1,450 meters, April 23, 1939 (Macintyre).

The present fly is entirely different from other described species of the subgenus, differing especially in the structure of the male hypopygium and particularly of the phallosome. The most similar form is *Gonomyia* (*Progonomyia*) *velutina* Alexander, which differs in the wing pattern and in all details of structure of the male hypopygium.

Genus *Cryptolabis* Osten Sacken

Cryptolabis (Cryptolabis) alticola new species.

General coloration black, more or less pruinose; lateral pretergites abruptly yellowish white; legs black; wings with a strong brownish tinge, the prearcular and costal fields yellow; *Rs* very long; male hypopygium with the dististyle large and conspicuous, exserted, consisting of an outer flattened setuliferous blade and a bispinous inner body; tergal plate bearing conspicuous lateral arms that terminate in several strong setæ; ædeagus long and slender.

MALE.—Length about 4.5 mm.; wing 5.2 mm.

Rostrum and palpi black. Antennæ brownish black; flagellar segments oval, with conspicuous verticils. Head black, presumably pruinose in fresh specimens.

Pronotum, mesonotum and pleura of the unique type dull black, the surface presumably more or less pruinose in fresh specimens; pretergites abruptly and conspicuously yellowish white. Halteres brown, the apex of knob brighter. Legs black, with relatively conspicuous suberect setæ. Wings with a strong brown tinge, the prearcular and costal fields yellow; axillary region restrictedly infuscated; veins and macrotrichia brown. Macrotrichia of cells relatively abundant, beyond the cord extending from outer end of cell R_2 to cell M_4, in the radial field involving all of the cells with the exception of the basal fourth to fifth. Venation: *Sc* relatively short, Sc_1 ending some distance before the end of *Rs*; *Rs* very long, exceeding in length vein R_3; R_{2+3+4} at origin nearly perpendicular to *Rs*, subequal in length to R_{2+3}; cell M_3 deep; *m-cu* at near midlength of M_{3+4}; vein *2nd A* gently sinuous.

Abdomen brownish black; hypopygium black. Male hypopygium with the dististyle large and conspicuous, exserted; consisting of an outer fleshy lobe or blade that may represent a separate style, and the main body of the style itself; outer blade flattened, densely covered with short setæ; inner portion of style with apex dilated into a truncated portion, the outer margin with two strong blackened spinous points, the more basal one erect, the outer spine more appressed. What appears to be the tergite appears as a transverse plate with the median portion strongly produced into a rounded lobe, the lateral arms appearing as strong cylindrical lobes that are directed strongly

mesad and then caudad, the tips with about seven elongate setæ. Ædeagus unusually long and slender, blackened, transversely corrugated.

Holotype, ♂, Hacienda Talahua, Bolivar, altitude 3,100 meters, April 28, 1939 (Brown).

Cryptolabis (*Cryptolabis*) *alticola* is entirely different from the other described species of the genus. It is most similar to species such as *C.* (*C.*) *chilotanica* Alexander, of southern Chile, yet very distinct in the structure of the male hypopygium. For a discussion of the type locality, consult Brown (Ann. Ent. Soc. Amer., 34: 848; 1941).

TWO NEW SUBSPECIES OF *EVERES COMYNTAS* GODART (LEPIDOPTERA, LYCÆNIDÆ)

BY HARRY K. CLENCH
CAMBRIDGE, MASS.

Two races of this wide-ranging species have recently come to my attention, one from South Dakota and one from Montana.

Everes comyntas valeriæ, new subspecies

UPPERSIDE:

Male. Both wings slightly purplish blue. *Fore wing* with a narrow dark border on the outer margin. Costa and costal veins pencilled with light blue. *Hind wing* with an internervural row of small spots on the outer margin. Costa dark bordered. Cu_2 with a short tail. *Fringe* of fore wing dark basally, white outwardly; of the hind wing white.

Female. Both wings brown. Base of each dark blue. Hind wing with a black spot in the Cu_1-Cu_2 interspace basally bordered by a shallow, rather dull orange lunule. A thin marginal pale bluish line borders the outer margin, interrupted at the veins, basal to which is a similar but scalloped and more obscure line. The two outline a series of internervural dark spots. Occasionally these lines are very faint, and the row of spots consequently almost indistinguishable.

UNDERSIDE:

Male. Ground color grayish tan. All spots arranged as in typical *comyntas*, but with the post-discal series usually rounder and darker—occasionally very heavy. The orange over the two spots in the M_3-Cu_1-Cu_2 interspaces of the hind wing is usually faint, although stronger in the latter than in the former. On this same wing, just basal to the marginal compound border, the ground color is white between the veins.

Female. Similar to the male.

Length of fore wing: Male, 11.5–13.5 mm.; Female, 10–12.5 mm.

Holotype, male, near Lead, South Dakota, June 22, 1939 (V. H. and A. C. Frederick).

Allotype, female, Terry Peak, South Dakota, el. 5200+ feet, June 24, 1939 (V. H. and A. C. Frederick).

Paratypes, 1 male, same data as holotype; 1 male and 2 females, same data as allotype; 1 female, Harney Peak, el. 5200+ feet, June 25, 1939 (A. C. Frederick); 31 males, 3 females, Spearfish Canyon and vicinity, el. 5200+ feet, as follows: 3 males, June 26,

27, and July 1, 1939, resp. (V. H. and A. C. Frederick); 15 males, 2 females, June 29, 1942 (A. C. Frederick); 13 males and 1 female, June 30, 1942 (A. C. Frederick); 17 males, Icebox Canyon, June 29, 1942 (A. C. Frederick). All localities in the Black Hills, South Dakota.

Holotype and allotype no. 25934 in the collection of the Museum of Comparative Zoölogy. Paratypes in the collection of Mr. Frederick and of the author.

Remarks. This subspecies appears to be most similar to the southwestern race *herrii* Grinnell[1] from which it differs in the following particulars: the black border on the wings above in the male is slightly thinner. This is most apparent on the hind wing, where the border in *herrii* is thick enough to include the internervural spots, while in *valeriæ* these spots are almost always free. There is no orange lunule on the hind wing above, an almost constant feature of *herrii*, and even more prominent in typical *comyntas*, but more variable in the latter. The ground color below in both sexes appears to be a little darker. The female of *valeriæ* is largely blackish brown above, with a rather dark basal blue shading, while in *herrii* both wings are rather extensively blue above. The orange lunules above are smaller in females of *valeriæ* than in those of *herrii*.

This subspecies appears to be quite variable. One male has a tiny orange lunule in the Cu_1–Cu_2 interspace above—the only indication of it in the whole type series. The same specimen and one or two others have the marginal border on both wings thickened, that on the hind wing including the submarginal spots. Below, the intensity of the spots varies considerably. One specimen has the submarginal series of lunules in the compound border enlarged and very dark, giving the insect a most peculiar appearance. The post-discal series of spots may be enlarged or reduced.

This subspecies is named for Mrs. A. C. Frederick, who materially assisted her husband in collecting the type series.

Everes comyntas albrighti, new subspecies

UPPERSIDE:

Male. Uniform violet-blue on both wings. *Fore wing* with a very narrow dark marginal border. *Hind wing* also with this border, and in addition,

[1] Can. Ent., 33: 192, 1901.

an almost obsolete row of small dashes, the heaviest in the Cu_1-Cu_2 interspace.

Female. Uniform brown on both wings. Base of fore wing blue. On the hind wing, in the Cu_1-Cu_2 interspace, a faint orange lunule surmounts a tiny dark spot.

UNDERSIDE:

Male. *Fore wing* dirty white, with a broad costal border of dark grayish scaling. The marginal compound border is almost obsolete, save for a few dark scales. A post-discal row of black spots, large and distinct, runs from costa to inner margin, the costal ones usually obsolete. Cell closed by a dark dash. *Hind wing* with a brownish gray ground color, fading on the outer margin. The submarginal border is, as in the fore wing, almost completely absent. The post discal series, the cell end bar, and the basal spots are also nearly gone, but their positions are shown by whitened areas in the gray. In the Cu_1-Cu_2 interspace is a small black spot, obscurely scaled with metallic, and capped by a tiny orange crescent.

Female. The single female examined shows a very similar appearance. The post discal series of spots on the fore wing is represented, however, only by spots from M_3 to the inner margin. The costal gray-brown on this wing extends down to M_3.

Length of fore wing: Male, 11–11.5 mm.; female, 11 mm.

Holotype, male, Kings Hill, Montana, July 9, 1939 (from C. C. Albright).

Allotype, female, same data.

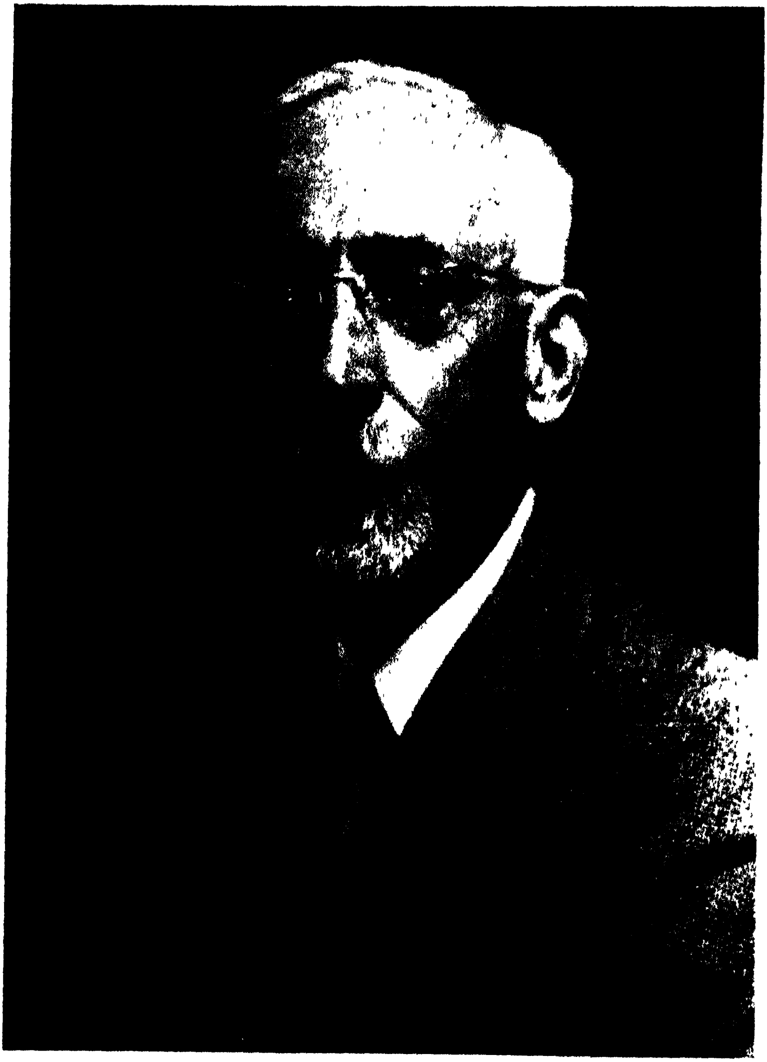
Paratypes, two males, same data.

Holotype and allotype to be deposited in the collection of the Museum of Comparative Zoölogy. One paratype in the collection of Mr. C. F. dos Passos. One paratype in the collection of the author.

Remarks. This subspecies differs from all other North American *Everes* thus far known in the grayish costal shading on the fore wing below, and in the gray ground color of the hind wing below. This subspecies appears to be closer in appearance to northern specimens of *amyntula* Boisd.[2] since several of its characters correspond quite closely to that species, such as the narrow margin above, reduced maculation below (aside from the gray ground color) and reduced orange in both sexes.

This subspecies is named for Dr. C. C. Albright, of Great Falls, Montana, from whom the specimens were obtained.

[2] Ann. Soc. Ent. France, 10 (2): 294, 1852.



FRANK EUGENE LUTZ

FRANK EUGENE LUTZ

1879–1943

Frank E. Lutz, the son of Martin P. Lutz and Anna Amelia (Brockway) Lutz, was born in Bloomsburg, Pa., on September 15, 1879. His early education took place in the public schools and the Bloomsburg State Normal School. From Haverford College in 1900 he received his A.B. degree. During his first two years in college he specialized in mathematics, upon the advice of his father, who, being an insurance agent, was impressed by the large earnings of life insurance actuaries. However, after two years the boy decided to go into medicine and so mathematics was dropped for biology. With college over his biology teacher, H. S. Pratt, advised him to go into biometry in view of his training in both mathematics and biology. This he did by going to see Dr. C. B. Davenport of the University of Chicago, who had charge of a summer biological laboratory at Cold Spring Harbor. At this laboratory Frank E. Lutz waited on tables and counted the grooves on scallop shells, finally publishing his first paper, a very short one, entitled "A Study in the Variations in the Number of Grooves upon the Shells of *Pecten irradiens* (Lam.)" in Science in 1900. Although brief, this paper helped him to get a scholarship at the University of Chicago where he obtained his A.M. in 1902. While working, as biologist for the North Shore Improvement Association, in mosquito control on the north shore of Long Island, he earned enough money to go to London (Eng.) where he studied under Karl Pearson. From September 1902 to June 1903 he was a student in London and Berlin.

From 1904 to 1909 he was employed as resident investigator at the Station for Experimental Evolution (Carnegie Institution) at Cold Spring Harbor, N. Y., where he did research work on heredity. Within this period, or in 1907, he obtained his Ph.D. from the University of Chicago for his dissertation on "The Variation and Correlation of Certain Taxonomic Characters of Gryllus," and at the beginning of this period, or on December 30, 1904, he married Martha Ellen Brobson, of Philadelphia, Pa.

Dr. Lutz then entered the employ of The American Museum of Natural History in 1909 as assistant curator in the department of invertebrate zoology. From 1917 to 1921 he served as associate curator and in 1921, when the department of entomology was created, he was appointed curator. For 22 years, or until his death at the age of 64 on the morning of November 27, 1943, at Harkness Pavilion, New York City, after an illness of several weeks, Dr. Lutz continued as chairman and curator of the department of insects and spiders.

After coming to the American Museum of Natural History his activity in biometrics declined and was replaced by an absorbing interest in insects, although he never had any college training in entomology and although several of his early museum papers dealt with the history of Antarctic explorations and with the string-figures of Patamana Indians. Under Dr. Lutz's leadership a large exhibition and study collection of insects was assembled, now numbering approximately 2,000,000 specimens. Many of these collections were made by Dr. Lutz during the course of 23 field expeditions to various parts of the United States and to South and Central America and the West Indies. These expeditions started in 1908 with a trip to Cuba and Mexico, and after he entered the employ of the Museum, 23 expeditions were made. The first took place in 1911 to the West Indies, British Guiana and Florida, and the last in 1941 to California. Between these dates, Dr. Lutz collected and made observations in Florida, Louisiana, Texas, California, Colorado, Wyoming, Utah, Idaho, Panama, Porto Rico, Cuba and British Guiana. In all five trips were made to the West Indies, five to Panama, five to Florida and eight to the western part of the United States. Some of these western trips were made in a special Museum truck-like automobile which Dr. Lutz had outfitted with equipment for collecting and living out-of-doors, making him independent of hotels and trains. In addition, he took an active part in Museum affairs and commttees and was chairman of publications and editor of the Museum's Bulletin and Memoirs from 1917 to 1929. From 1925 to 1928 he directed the Station for the Study of Insects at Tuxedo, N. Y., and was one of the nation's leading exponents for nature trails and museums.

During the summer of 1926 he began the first trailside museum of its kind at Bear Mountain, N. Y., and was called upon by many organizations for advice in establishing similar trails in parks and wild-life areas in various parts of the United States. I distinctly recall his enthusiasm upon this subject, when in company with Mr. E. L. Dickerson I paid him a visit at Tuxedo when the station there was half completed. Dr. Lutz was so anixous to get things finished that he would not go with us for lunch, preferring to dine quickly upon some pieces of bread over which he had broken a raw egg, a nutritious, if not appetizing mixture.

In planning the arrangement of the insect exhibits at the Museum, Dr. Lutz attempted not only to supply information about insects, but to interest the visitor in entomology as well. About 1915 the plan of the Hall of Insect Life involved exhibits, with continuity, covering ontogeny, anatomy, physiology, taxonomy, phylogeny, life-histories, insect associations, insect enemies and evolution. And in addition, there were exhibits on miscellaneous topics such as insect architecture, insects as food, medicine, social insects, etc., etc. Later as exhibit methods changed there were originated by Dr. Lutz various habitat groups. Dr. Lutz tells of the early days of his department in "Natural History," May–June, 1924, under the title "Amateur Entomologists and the Museum." During his administration the insect collection was increased by gifts, purchases and expeditions, well over a million specimens.

For many years Dr. Lutz took an active part in the affairs of the New York Entomological Society, serving as president in 1925 and 1926 and on the Publication Committee for 20 years. For a long period the meetings were held in Dr. Lutz's room on the third floor of the Museum and there, surrounded by preserved spiderwebs, Dr. Lutz's zoo of living insects and entomological books and paraphernalia, many interesting entomological discussions took place, in which he always participated.

A glance at Dr. Lutz's published writings indicates that from 1910 on, they were concerned exclusively with insects, and spiders, principally the former. In both his popular and scientific writings he covered such topics as geographic distribution, insect sounds, a study of ultraviolet in relation to flower-visiting habits

of insects, wind and the direction of insect flight, insect life in thermal waters, and other subjects involving the biology and behavior of insects. He was not interested in economic entomology and he believed that more intensive work on the biology of insects was needed in view of the fact that comparatively little is known even about many of our most common species. Important contributions were made by Lutz in the field of insect behavior through his research work on insect reactions to ultraviolet, on the training of bees to come to certain ultraviolet wavelengths and patterns for food, on his recordings and sound motion pictures of insect sounds and insect behavior under various atmospheric pressures. Such work required not only a thoughtful and enquiring mind, an awareness of the pitfalls in conclusions, but ingenuity in inventing mechanical devices needed for the tests. These requirements Dr. Lutz possessed. In 1923 he was awarded the Morrison Prize for his essay on "The Colors of Flowers and the Vision of Insects with Special Reference to Ultraviolet." In addition to his research work he did much to popularize entomology and nature study. Tens of thousands of persons use his "Field Book of Insects." This was first published in 1918. A second edition was published in 1921 and a third in 1935. Its royalties put Dr. Lutz's four children through college.

In 1941 he wrote his last book entitled, "A Lot of Insects." This embodies accounts of the insects that, for the most part, were the objects of Dr. Lutz's curiosity, experimentation, and entertainment over a period of many years, and includes his sound and humorous entomological philosophy—all expressed interestingly and in a lucid style. Dr. Lutz approached all his problems from a stiumulating and thought-provoking viewpoint and this makes for fascinating reading.

Dr. Lutz was a Fellow of the New York Academy of Sciences and the American Association for the Advancement of Science, a charter member of the Entomological Society of America and its president in 1927, a member of the American Society of Zoologists, the American Society of Naturalists, the Ecological Society of America, Sigma Xi, Phi Beta Kappa, New York Zoological Society, and the New York Entomological Society, his presidency of the latter society having already been noted. He

was an advisor to the Buffalo Society of Natural Sciences and in 1937 a lecturer in Columbia University. He also served as chairman of the committee on Biological Relations Between Flowers and Insects of the National Research Council.

Dr. Lutz made his home in New Jersey and funeral services were held at his residence, 13 North Central Avenue, Ramsey, New Jersey, on November 29, 1943. He is survived by his widow, Mrs. Martha Ellen Brobson Lutz and four children, a son, Frank Brobson Lutz, and three daughters, Anna Lutz, Ensign Laura Lutz of the WAVES, and Mrs. Boyd Sherman.

These few paragraphs are but an inadequate summary of some of the things accomplished by Dr. Lutz during his lifetime. They fail to record many activites of which there are no records, except in the memories of his friends. They fail to record the happiness that Dr. Lutz's chosen life-work brought to him, and the pleasure that was his in creating problems and then solving them. And they fail to mention his amiable and quizzical philosophy of biological theories, flashes of which are apparent in his writings. In a review of Dr. Lutz's last book, and speaking of his "Field Book of Insects" as well, Dr. H. M. Parshley said: "They mirror a rare and admirable personality, a man of genuine good will, a humorist, and one of a remarkable generation of American naturalists."—HARRY B. WEISS.

BIBLIOGRAPHY OF FRANK E. LUTZ*

BY ANNETTE L. BACON

1900. A study in the variations in the number of grooves upon the shells of *Pecten irradians* (Lam.). Science, 12: 373.

1902. Report of Mr. Frank E. Lutz, Biologist. North Shore Improvement Association. Reports on plans for the extermination of mosquitoes of the north shore of Long Island between Hempstead Harbor and Cold Spring Harbor, p. 42–56.

The ecology of insect sounds. Can. Ent., 34: 64–66.

Inheritance of color among pointers. Science, 15: 571–572. (With Eliz. B. Meek.)

1903. Note on the influence of change in sex on the intensity of heredity. Biometrika, 2: 237–240.

Assortative mating in man, a cooperative study. Biometrika, 2: 481–498.

1904. Variation in bees. Biol. Bull., 6: 217–219.

1905. Biometry. Jour. Phil. Psych. and Sci. Meth., 2: 12–15.

Assortative mating in man. Science, 22: 249–250.

1906. Preserving spiders' webs. Science, 23: 391.

The tegminal position in *Gryllus*. Can. Ent., 38: 207–209.

1907. The merits of the fruit fly (*Drosophila ampelophila*). School Science and Math., 7: 672–673.

1908. Notes and literature: The effect of environment upon animals. Amer. Nat., 42: 60–61.

The inheritance of the manner of clasping the hands. Amer. Nat., 42: 195–196.

Notes on the inheritance of variations in the color pattern of *Crioceris asparagi*. Psyche, 15: 50–52.

The variation and correlations of certain taxonomic characters of *Gryllus*. Carnegie Inst. Wash., Pub. No. 101, 63 p.

Combinations of alternative and blending inheritance. Science, 28: 317–318.

1909. Notes and literature: The effect of environment upon animals. Amer. Nat., 43: 55–57.

Notes and literature: The effect of environment upon animals. Amer. Nat., 43: 248–251.

Experimental work with pomace flies. Amer. Mus. Jour., 9: 234–236.

1910. A brief history of antarctic exploration. A.M.N.H. Guide Leaflet 31, 27 p.

The annual scourge of flies and mosquitoes. Amer. Mus. Jour., 10: 183–185.

* Exclusive of book reviews and annual reports.

1911. Experiments with *Drosophila ampelophila* concerning evolution. Carnegie Inst. Wash., Pub. No. 143, 40 p.
Relation between habit and structure in the insect world. Amer. Mus. Jour., 11: 27–28.
Flea carriers of the plague. Amer. Mus. Jour., 11: 95–98.
Notes and literature: Mimicry. Amer. Nat., 45: 190–192.
Index to the generic names in Volume XXIX, Dr. Petrunkevitch's "Catalogue of Spiders of North, Central and South America and Adjacent Islands." Bull. A.M.N.H., 29:793–809.

1912. Inheritance of abnormal wing-venation in *Drosophila*. Proc. VII International Zool. Congress (1907), p. 411–419. (Advance reprint, 1910.)
String-figures from the Patomana Indians of British Guiana. Anthrop. Papers A.M.N.H., 12: 1–14.
String-figures from the Upper Potaro. Timehri. Jour. Roy. Agric. Com. Soc. British Guiana, 2(ser. 3): 117–127.
Do butterflies migrate? Amer. Mus. Jour., 12: 106–108.
The importance of insects. Amer. Mus. Jour., 12: 253–254.

1913. Experiments concerning the sexual difference in the wing length of *Drosophila ampelophila*. Jour. Exper. Zool., 14: 267–273.
Factors in aquatic environments. Jour. N. Y. Ent. Soc., 21: 1–4.
The distribution of Occidental spiders. Science, 37: 567–568.
The life of the butterfly. House and Garden, August, p. 89–92.

1914. Humidity—a neglected factor in environmental work. Amer. Nat., 48: 122–128.
Collecting in Cuba. Amer. Mus. Jour., 14: 99–106.
Biological notes concerning *Drosophila ampelophila*. Jour. N. Y. Ent. Soc., 22: 134–138.
Our common butterflies. A.M.N.H. Guide Leaflet 38, 25 p. (With F. E. Watson.) 4th ed., 1923, 31 p.; 5th ed., 1926, 21 p.; 7th ed., 1941, 21 p.
How to collect and preserve insects. A.M.N.H. Guide Leaflet 39, 21 p. 3rd ed., 1917, 22 p.; 4th ed., 1920, 22 p.; 5th ed., 1924, 27 p.; 8th ed., 1936, 27 p.

1915. List of Greater Antillean spiders with notes on their distribution. Annals N. Y. Acad. Sci., 26: 71–148.
Fragments of spider lore. Amer. Mus. Jour., 15: 424–426.
Experiments with *Drosophila ampelophila* concerning natural selection. Bull. A.M.N.H., 34: 605–624.
Outline plan of the hall of insect life. A.M.N.H. Circular, 4 p.

1916. Heredity and sex; Mendelism and some of its recent developments. Amer. Mus. Jour., 16: 228–242.
Faunal dispersal. Amer. Nat., 50: 374–384.
The geographic distribution of Bombidæ (Hymenoptera) with notes on certain species of Boreal America. Bull. A.M.N.H., 35: 501–521.

Insects, an inexhaustible and relatively untouched field for recreation or research. Amer. Mus. Jour., 16: 525–532.

1917. Heredity and sex. Mendelism and some of its recent developments Scientific American Supplement, 84 (2169) : 56–58.

1918. Field book of insects. G. P. Putnam's Sons. New York, N. Y. 509 p.

General rules for the preparation of manuscript for the Bulletin and Memoirs of the American Museum of Natural History. A.M.N.H. Special Brochure No. 2, 14 p.

Insects and disease. A.M.N.H. Guide Leaflet 48, 73 p. (With C.-E. A. Winslow.)

The control of insects injurious to gardens. A.M.N.H. Circular, 3 p.

1919. Scientific zoological publications of the American Museum for 1918. Summary of work on invertebrates, fishes, amphibians, and birds. Nat. Hist., 19: 341–346.

Scientific zoological publications of the American Museum. Summary of work on fossil mammals. Nat. Hist., 19: 731–733.

1920. Scientific zoological publications of the American Museum. Summary of work on whales. Nat. Hist., 20: 107–109.

An entomologist in Colorado. Nat. Hist., 20: 312–325.

Our most brilliant butterflies. Country Life, 38 (4) : 27–33. (With F. E. Watson).

Foreign insects newly come to America. Nat. Hist., 20: 501–502.

Notes on the distribution and bibliography of North American bees of the families Apidæ, Meliponidæ, Bombidæ, Euglossidæ, and Anthophoridæ. Bull. A.M.N.H., 42: 491–641. (With T. D. A. Cockerell.)

How crickets chirp. The Woodcraft Totem Board, 4 (4) : 3.

How some insects walk on water. The Woodcraft Totem Board, 4 (5) : 3.

How moths and butterflies spend the winter. The Woodcraft Totem Board, 4 (6) : 3.

1921. How do insects make galls. The Woodcraft Totem Board, 4 (7) : 3.

How bees make honey. The Woodcraft Totem Board, 4 (8) : 7.

How whales spout. The Woodcraft Totem Board, 4 (9) : 3.

How to collect insects. The Woodcraft Totem Board, 4 (10) : 3.

How to preserve insects. The Woodcraft Totem Board, 4 (11) : 3.

Geographic average, a suggested method for the study of distribution. Amer. Mus. Novitates, 5, 7 p.

Field book of insects. Second edition. G. P. Putnam's Sons. New York, N. Y. 562 p.

1922. The reaction of *Drosophila* to ultraviolet. Science, 55: 519. (With F. K. Richtmyer.)

Altitude in Colorado and geographical distribution. Bull. A.M.N.H., 46: 335–366.

1923. Flowers and their insect visitors. Nat. Hist., 23: 125–134.

1924. Apparently non-selective characters and combinations of characters, including a study of ultraviolet in relation to the flower-visiting habits of insects. Annals N. Y. Acad. Sci., 29: 181–283.

Amateur entomologist and the Museum. A survey, from the half-century mark, of the Department of Entomology, American Museum. Nat. Hist., 24: 337–346.

Hunting stingless bees where east seems to be west. Nat. Hist., 24: 494–508.

Insect sounds. Bull. A.M.N.H., 50: 333–372.

1925. The new insect groups in the American Museum. Nat. Hist., 25: 126–135.

1926. Nature trails, an experiment in out-door education. A.M.N.H. Misc. Pub. 21, 36 p. Second edition, 1931.

Taking nature lore to the public. Nat. Hist., 26: 111–123.

The friendly insects. Nat. Hist., 26: 147–151.

Principal orders of insects. Nat. Hist., 26: 164, with chart. (With A. J. Mutchler.)

Our common butterflies. Nat. Hist., 26: 165–183. (With F. E. Watson.) (Reprint of Guide Leaflet 38.)

Insect sounds. Nat. Hist., 26: 206–213.

A nature trail in the sky. Nat. Hist., 26: 411–428.

1927. The still-open road. Nat. Hist., 27: 373–382.

Wind and the direction of insect flight. Amer. Mus. Novitates 291, 4 p.

A much-abused but still cheerful cricket. Jour. N. Y. Ent. Soc., 35: 307–308.

1928. A new species of bacteria and the gall of an aphid. Amer. Mus. Novitates 305, 4 p. (With F. Martin Brown.)

Little "beasts of prey" of the insect world. Nat. Hist., 28: 188–190.

Insects that erect tents. Nat. Hist., 28: 264–268.

1929. Experiments with "wonder creatures." Nat. Hist., 29: 160–168.

Observations on leaf-cutting ants. Amer. Mus. Novitates 388, 21 p.

1930. An analysis by movietone of a cricket's chirp (*Gryllus assimilis*). Amer. Mus. Novitates 420, 14 p. (With W. R. Hicks.)

Caddis-fly larvæ as masons and builders. Nat. Hist., 30: 276–281.

Aquatic insect pets. Nat. Hist., 30: 389–401.

1931. Light as a factor in controlling the start of daily activity of a wren and stingless bees. Amer. Mus. Novitates 468, 9 p.

Insects *vs.* the people. Nat. Hist., 31: 49–57.

In defense of insects. Sci. Mo., 32: 367–369. (Science Service Radio Talks.) (Reprint of Insects *vs.* the people.)

Insects *vs.* the people. Condensed from The Scientific Monthly, April, 1931. Readers Digest, 19: 359–360, 363.

In defense of insects. Article 28 in Science Today, edited by Watson Davis, Harcourt Brace and Co., p. 184–188 (reprint).

A simple evaporimeter and some data obtained by its use in the Canal Zone. Ecology, 12: 445–448.

Notes on the animal life of thermal waters in the Yellowstone National Park. Amer. Mus. Novitates 498, 10 p.

1932. Our ignorance concerning insects. Can. Ent., 64: 25–29, 49–56 and 73–78.

Experiments with Orthoptera concerning diurnal rhythm. Amer. Mus. Novitates 550, 24 p.

1933. Experiments with ''stingless bees'' (*Trigona cressoni parastigma*) concerning their ability to distinguish ultraviolet patterns. Amer. Mus. Novitates 641, 26 p.

''Invisible'' colors of flowers and butterflies. Nat. Hist., 33: 565–576.

1934. The ''buckwheat problem'' and the behavior of the honey bee. Amer. Mus. Novitates, 688, 10 p.

Reactions of Drosophila to 2537 Å radiation. Amer. Mus. Novitates 706, 14 p. (With E. N. Grisewood.)

World of the bee remains a mystery. New York Times Magazine, Aug. 19, p. 12 and 15.

From low to high. Grand Canyon Nature Notes, 9: 327–329.

1935. Field book of insects. Third edition. G. P. Putnam's Sons. New York, N. Y. 510 p.

1936. How about the tent caterpillar? Nat. Hist., 37: 149–158.

1937. Culture methods for invertebrate animals. 590 p. By P. S. Galtsoff, F. E. Lutz, P. S. Welch, J. G. Needham, *et al.* Comstock Pub. Co. Ithaca, N. Y. Collecting and rearing terrestrial and fresh-water invertebrates, by Lutz, Needham, Welch. p. 40–50.

1938. The insect glee club at the microphone. Nat. Hist., 42: 338–345, 378.

1939. Big bees. School Nature League Bull. No. 10 (ser. 9), 3 p.

1941. The truth about termites. Nat. Hist., 48: 113–115.

A lot of insects. G. P. Putnam's Sons. New York, N. Y. 304 p.

1942. Insects, ticks and human diseases. A.M.N.H. Guide Leaflet No. 113, 38 p. (With C. H. Curran.)

LEPIDOPTERA FROM WESTERN PERU AND ECUADOR

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The occasion of this note is a little lot of Lepidoptera collected by Mr. and Mrs. D. L. Frizzell in the arid northwest corner of Peru, and Puna Id., Ecuador. While not many, the striking character of the fauna is indicated by the presence of two new Citheroniidæ, and the region evidently is worth intensive collecting. Among the normal and widespread things, may be mentioned *Cœa acheronta, Herse convolvuli* from the Pariñas Valley, near Negritos, Peru; *Pholus labruscæ, Celerio annei, Utetheisa ornatrix* from the Pariñas Valley; *Hymenia fascialis, Eudioptis hyalinata* and *Conchylodes arcifera* from the Quebrada Mogollon.

The following are worthy of more specific mention. A female Monarch shows the dull color and heavy black of the Lima females. Single females of *Ascia monuste* from Negritos, Peru, and Puna Id., Ecuador, suggest but hardly prove a racial difference.

Lycæna ramon Dognin. Pariñas Valley, May 7, 1939. This species was described from near Loja, Ecuador, a high temperate and semiarid locality in the heart of the Andes[1] but is equally at home at sea level, where I took it commonly at Lima. It also occurs on the western slope of the Andes at Chosica and Matucana, and we have a specimen from Eten, a little north of Lima—so it doubtless covers the whole arid area of western Ecuador and at least northern Peru. We received the Eten specimen as *hanno,* and other material may be floating around under that name, but it is easily recognized by the ocelli on the hind wing below—two larger between M_3 and Cu_2, and two only a little smaller behind Cu_2. The following key to the American species of *Lycæna,* subgenus *Hemiargus* will place it more precisely.

[1] Brown, Ann. Ent. Soc. Am., 34: 832.

1. Postmedial spots of fore wing below large and black, contrasting with the small and fuscous subterminal series . . . . *isola*
—. Pm. spots of fore wing similar to subterminal ones 2
2. Hind wing below with a large ocellus in cell M_3 (cell 3 of Herrich-Schaeffer system), similar to the one behind it 3
—. Hind wing with no ocellus in cell M_3 5
3. Inner half of hind wing below contrastingly darkened, nearly obliterating the usual marks, which are much enlarged in this area; four small ocelli . . . . *martha*
—. Hind wing with ground all one color, the fuscous spotting generally uniform 4
4. Two ocelli in anal area (behind Cu_2) about two-thirds as large as the ones in front of it and similar . . . *ramon*
—. These ocelli small with a small silver spot only, or dull and similar to the anterior subterminal markings . *zachaeina*
5. Anal area with a single large ocellus, similar to the one in front of Cu_2 6
—. Anal area with two subequal and inconspicuous spots or ocelli, about as in *zachaeina*, or none 8
6. Gray-brown below with spots all small, subequal and grayish *bahamensis*
—. Pale gray below 7
7. Hind wing below, and above in female, with a very broad white submarginal band; all spots below small and similar . *dominica*
—. Hind wing below with less conspicuous white submarginal band or none; three of the dark spots black and conspicuous *ammon* (*catilina* auct.)
8. Largely gray above; hind wing with slight tail and anal lobe *bornoi*
—. Mostly blue above; hind wing evenly rounded . *hanno* (*catilina*)

Goniurus jethira Butler. Easily recognized by the very large honey-yellow spots, which are even larger in this specimen than in the type. (Lep. Exot., p. 65, pl. 25, fig. 4). Pariñas Valley, May 7, 1939. The original locality was merely "Peru" but I did not take it either at Lima or in the Chanchamayo, and suspect it is a specialty of the arid Northwest.

Arsenura harrietæ, new species

Closely similar to *A. richardsoni* Druce in major features; the fuscous ground very lightly dotted with black, most definitely on posterior half of median area. Antemedial of two widely separated blackish lines, the inner nearly straight and outer much bowed out below cell, as in *richardsoni*, but with heavier blackish filling, and the lines themselves more contrasting; postmedial line much further out, nearer to subterminal than to discal lunule, blackish, more definite and more bowed out opposite lower angle of cell, the median area conspicuously whitish toward inner margin; the following line (subterminal in position, but probably morphologically the outer postmedian) black, defined outwardly by a clay colored line, which is much finer and more

contrasting than the defining pale shade in *richardsoni;* course much as in *richardsoni,* but closer to margin, especially on costal third, and not nearly as much extended toward base on inner margin; subterminal area not pale as in *richardsoni,* but as dark as ground on fore wing and contrastingly blackish on hind wing, with much paler yellow-brown terminal area. Subapical black spot shorter than in *richardsoni,* not distinctly defined with white; the terminal area below it vaguely shading between dull and red brown, without the contrasting red-brown wedges of *richardsoni.* Discal lunule black and contrasting with central tawny lunule, as in *richardsoni,* but without the tawny bar extending from its outer side.

Hind wing generally similar to fore wing, but with only a faint darker antemedial shade in place of the double line and dark filling, this shade incorporating the faint discal bar (which is more distinct in *richardsoni*); postmedial band as on fore wing, much more conspicuous than in *richardsoni;* the outer pattern differing from the fore wing as noted. Wing form rounder than in *richardsoni,* the apex of fore wing and angle of hind wing less extended. Under side much less mottled than *richardsoni,* with three wavy outer bands, varying from obsolescent to rather conspicuous, the outer strongest and middle one weakest. Body plain brown as in *richardsoni.*

Expanse 92–110 mm., much smaller than *richardsoni.*

Puna Id., Ecuador; type and two paratypes in collection Cornell University.

This may possibly be a race of *richardsoni,* but the discontinuous distribution, different wing form and many differences in pattern suggest rather a good species. The following skeleton key will place it in the genus:

1. Antemedial line double, of an outwardly oblique inner and a strongly excurved outer element, the latter sometimes faint; st. space on posterior half of fore wing and hind wing much broader than terminal area 2
–. Am. line single, straight and outwardly oblique; both wings with a sharply defined even slender pale marginal stripe **romulus*
–. Am. line single, outcurved or angled, inwardly oblique to inner margin; st. space narrower, usually much narrower than terminal space, except sometimes for narrow extensions 4
2. Fore wing roundly falcate and deeply excavate below apex; hind wing with tooth large, 12 mm. long on anterior side; hind wing with inner st. line deeply sinuate, passing half way between margin and cell at M_1 . . . . **championi*
–. Wings less irregular; st. line of hind wing crossing M_1 two-thirds way out to margin 3
3. Discal spot of fore wing with a simple orange central lunule; margin of wings hardly irregular . . . . **harrietae*

–. Discal spot of fore wing with a short extension of middle of outer side of lunule, forming a Greek *e*; tail of hind wing 6 mm. long. **richardsoni*

4. Hind wing at least with a series of dark spots or lunules in terminal area, wholly distinct from the subterminal complex; fore wing with black markings conspicuous in cells M_1 and almost always M_2, the upper usually joining to the apical pattern but conspicuous, the lower usually free 5

–. Hind wing without this series of markings, though often with somewhat similar extensions of the st. area; black patches in cells M_1 and M_2 normally absent, sometimes mere dashes, or lost in general blackish shading . . . 11

5. Generally smaller species (female alcmene expanding 140 mm.), head solid black, contrasting with the paler brown or fuscous thorax . 6

–. Larger species (160 mm. and often more); head with at least a contrasting pale bar over bases of antennæ . 8

6. Postmedial line not defined with pale; st. area expanded into a large patch, occupying two-thirds the area between st. line and margin in cells R_4 and R_5 *alcmene*

–. Pm. line conspicuously defined by a following dirty white shading; st. area below apex less extensive . . 7

7. Markings of fore wing corresponding to the admarginal lunules of hind wing taking the form of two similar large blotches in cells M_3 and Cu_1 (feet not seen) . *pandora*

–. This element of pattern taking the form of a waved diffuse admarginal line; tarsi concolorous dark brown . **angulata*

–. This element obsolete, except at anal angle, where it is not conspicuous; tarsi cream white, contrasting . . **xanthopus*

8. No black st. patch in cell M_2; pm. area of both wings heavily shaded with black; discal spot of fore wing lunulate; no admarginal spots on fore wing . . *sylla, hercules*

–. Cell M_2 heavily marked subterminally with black; discal spot a simple bar 9

9. No admarginal lunules on posterior part of fore wing; the black spot in M_2 fused with the blotch in cell M_1 *aspasia*

–. Spot in cell M_2 separate, conspicuous, and followed with dark shades in cells M_3 and Cu_1 similar to those on hind wing . 10

10. Ground with strong yellowish tint; the two black patches in cells M_1 and M_2 similar, very large, separated by hardly more than the light vein, and scaled heavily with blue .... **meander*

—. Ground with olive tint; the second black patch narrow and ovate. **biundulata*

11. Inner subterminal line nearly even, and marked with contrasting whitish dots on veins or more irregular whitish patches; antemedial line when distinct formed of a straight or concave bar across cell and a very oblique lower portion from lower side of cell to basal angle 12

—. Inner st. line more irregular, normally with two large scallops between M_3 and Cu_2, with only limited and irregular white marks; am. line when distinct with lower portion less set off from portion crossing cell, frequently in the form of a single excurved band 14

12. Lower segment of am. line conspicuous, in line with and more or less continuing the black shade subterminally across cell M_1; a conspicuous pale st. patch just below it in cell M_2 . *ponderosa*

—. Lower segment of am. line inconspicuous; no single pale st. patch 13

13. Outer margin strongly irregular; postmedial area contrasting bright chestnut brown . . . . *batesi*

—. Margins less irregular; ground rather even dull light brown. **crenulata*

—. Margins still less irregular; pm. area somewhat contrasting, but light brown . . . *arcaei*

14. Discal spot lunulate, with contrasting pale center; dentations of inner and outer st. lines if present not closely corresponding 15

—. Discal spots simple; the inner and outer st. lines closely parallel over the dentations at cells M_3 and Cu_1 16

15. Inner st. with distinct and outer with very strong dentations, the white accompanying shade irregular . **cymonia*

—. Inner st. line nearly straight, and with even accompanying white shade; outer st. obsolete *thomsoni*

16. Outer st. line with very strong, narrow black-filled dentations on both wings, three or four of them on fore wing similar *polyodonta*

—. Outer st. line closely fitted to inner, both without strong dentations, save for two in cells M_3 and Cu_1 of fore wing group **armida*

—. Intermediate; the two upper teeth on fore wing present, but only half as large as the two lower, and filled not with special black triangles but with extensions of the generally blackish contrasting pm. area; very large, expanding 175 mm. **archianassa*

In structural characters, the wing-form varies too widely in obviously closely related species to serve for major subdivision, but two groups are set apart by having pectinate antennæ, sylla and arcæi with their relatives—alternatives 5 and 12 of the key. The residue, so far as seen, and including *harrietæ,* have serrate and fasciculate antennæ.

Dysdæmonia species. There was badly broken material of a very striking undescribed Dysdæmonia, with scalloped wings. It will be described by Mr. Johnson, who has a better specimen from the same region.

* Species represented in coll. Cornell University, many of them the gift of Mr. Frank Johnson.

Givira tristani Schaus. A rubbed specimen from Puna Id. is this species or very close.

Euclea copac Schaus. Puna Id. Agrees so far as can be seen, but not good enough for certainty. The species was described merely from "Peru."

Seirocastnia elaphebolia Druce. Looks to me like a good species. Described from Ecuador.

Monodes convexa, new species

Superficially similar to the North American *festivoides* group, but with relatively much smaller body and arched fore wings. Structures of the normal Monodes, without sex-scaling; male antennæ ciliate, legs unmodified, with a rough tuft beyond middle of mid tibiæ; vestiture normal for Monodes, as described by Hampson, but with the posterior thoracic tuft extended back, almost completely covering the basal abdominal tuft, and roundly truncate behind. Palpi with second joint upturned only a little beyond middle of front, as also in normal species of Monodes.

Body fuscous, thorax somewhat mottled, with darker lower half of collar, the upper half of front, vertex and lower half of collar contrasting blackish in dark specimens; palpi with first and second joints with paler apices, the outer sides contrasting blackish in dark specimens. Fore wing gray, varying extremely in tint, light specimens with the terminal third much darker, dark ones sometimes with the costal area rather darker. Costa with numerous dark bars in light specimens, dark, cut with the pale gray ante- and postmedial lines in dark specimens, and with about four small whitish bars between postmedial and the pale apical shade. Subbasal line of vague paler powdery scaling, toward costa, toward inner margin represented by an oblique blackish bar; antemedial obscure, except for the contrasting pale bar at costa; postmedial represented by dark spots on veins, followed by minute whitish ones, broadly and evenly excurved on costal two thirds, then oblique in to inner margin and slightly concave. Subterminal obscure, sometimes indicated as the irregular boundary between a grayer terminal and browner subterminal area; orbicular and reniform spots large, the orbicular outlined with black except above, usually heavily before and behind; reniform very large, only partly outlined; the area before orb. blackish, the filling between orb. and ren. blackish or shaded with dark, without the sharp boundaries of the festivoides group, the space between ren. and postmedial line usually somewhat darkened, but without a blackish spot. Claviform minute, whitish, usually contrasting, heavily outlined with black, especially before and beyond. Apical oblique shade varying from obsolete to conspicuous, cream white to ash gray, with the basal half shaded with buff in light specimens and slightly warmer brown in dark ones; starting from pm. line opposite cell, curving up and widening in a horn shape, and ending on outer tenth of costa; partly edged behind with black. Terminal blackish dots, obscure in dark speci-

mens, preceded by whitish points, alternating with the pm. ones. Fringe powdery gray, the outer half rather smoother and less powdery. Hind wing dirty white, shading into fuscous on outer half; alula cream, clothed with large scales and conspicuous. Expanse 17–20 mm.

This species in normal specimens will run in Hampson's key to the *festivoides* group, from which it is distinguished by the total lack of warm coloring, much smaller body and arched fore wings, also in maculate forms by the less sharply defined blackish about the orbicular and reniform. It is probably close to *bogotana* Felder and *aphaidropa* Dyar (which are presumably merely color forms of each other) but is smaller, and none of our series are as pale as Felder's figure of *bogotana,* nor show the reddish shadings along costa of *aphaidropa.* It varies enormously, from specimens (males) with the basal two thirds luteous and only the outer third blackish, much like Felder's figure, to specimens (females) that are wholly suffused with smoky gray and coal black, with all the markings obsolescent. Such specimens will probably key out to *phæopera,* but differ from it and its relatives by the rather even dull gray, with the darker area between orbicular and reniform, and the paler apical area at least faintly visible.

The male genitalia of Monodes are extremely varied, and convexa resembles *nucicolora, grata* or *fusimacula* more closely than *festivoides,* having the valves slender, with a complicated basal chitinization composed of parts of sacculus, costa, and perhaps clasper, and sending a spike forward across the costa; weak clasper at a third way out, crossing costa; juxta slenderly extended as a complete anellus, and transtilla also bent into a round arch closely parallel to it. Ædœagus with two massive spines, formed of fused cornuti.

Holotype, male from Chosica, Peru, May 25, 1920. Numerous paratypes of both sexes, from Chosica and Lima, Peru, May 1920; a couple caught by Parish at Lima in 1915; and a pair from the Amotape Mts., N.W. Peru, collected by the Frizzells; all in collection Cornell University. I believe other specimens exist in collections, perhaps labelled bogotana, but the Lima fauna has been extraordinarily neglected, considering how many good collectors have passed through it or even used it for a base.

Cydosia phædra Druce. Puna Id.

Cobubatha numa Druce. Amotape Mts.

Dichochroma, new genus

Similar to the Pyraustine genus Dichogama. Vestiture of large, smooth scaling; palpi upturned to middle of front, close-scaled, slightly flattened against the front; the segments well marked off, third segment larger than in Dichogama, two-thirds as long as second, continuing the direction of second; maxillary palpi rough-scaled, flattened against the face, as in Dichogama. Tongue strong. Legs very short for a Pyraustine, as in Dichogama, mid tibia about as long as femur without trochanter, and tarsus hardly longer. Fore wing presumably with the long Arctiid-like frenulum hook of Dichogama (male not seen); R_3 and R_4 stalked, R_5 stalked with M_1, well separated from R_4, M_2 and M_3 stalked, Cu_1 parallel to M_3, arising well before end of cell. Hind wing without fringe on Cu; M_2 and $_3$ strongly stalked, as in *D. fernaldi*, but unlike the other Dichogamas at hand.

Third A of fore wing is strong and makes a wide loop, but I cannot see if it runs back into 2d A.

This genus is clearly a development of Dichogama, differing from it, and from all Pyraustinæ known to me in the stalked R_5 and M_1 (veins 6 and 7) and from most in the stalking of M_2 and M_3 in both wings. It is also far smaller than any Dichogama yet known, and is found on the Mainland, while Dichogama is essentially Antillean, only *D. diffusalis* not yet being known from the Antilles. In Hampson's key (Proc. Zool. Soc., 1898, 594) it will run to Hymenia or Macarætera, according to how the third segment of the palpus is interpreted, but has no real kinship to either. The stalked veins will easily separate it.

By the way there is no reason for marking several species of Dichogama "incertæ sedis" as Klima does in Lep. Cat. 89, p. 122. We have *colotha*, *fernaldi* and *gudmanni* from Porto Rico and they are normal Dichogamas, save for the stalked instead of approximate M_2 and M_3 in *fernaldi;* and *amabilis* and *bergii* show patterns that would hardly occur elsewhere; but *smithii*, unquestioned by Klima, is the well known Noctuid, *Casandria abseuzalis*, which I found common in Porto Rico.

Dichochroma muralis, new species

Head and thorax mouse gray, dusted with whitish scale-tips; thorax immaculate; shaft of antennæ blackish; palpi with first segment whitish, second mouse gray, but whitish along the ventral inner keel; third segment blackish with contrasting dirty white tip. Under side cream white, the front side of the fore legs fuscous. Abdomen above mouse gray, immaculate, below nearly white.

Fore wing mouse gray, immaculate but with pale scale-tips especially toward base, and sparsely overlaid with narrow whitish strap-shaped scales; fringe whitish. Hind wing translucent white with narrow and broken fuscous terminal line. Expanse 16 mm.

Amotape Mts., N. W. Peru, H. & D. L. Frizzell; type one female in coll. Cornell University.

In sum this little fauna from the north end of the arid coastal strip of South America is a curious one. While the typical material of this strip is present (*e.g.*, *Celerio annei* and *Monodes convexa*) there is also a definite Central American element (notably the Arsenura, which is closest to *A. richardsoni*), and a few species which now appear to be endemic, such as the undescribed Dysdæmonia, *Euclea copac* and *Dichochroma murina*. Plainly many more interesting things are due to come out of the area.

DROSOPHILA MELANURA, A NEW SPECIES OF THE MELANICA GROUP

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During most of the summer of 1941 the author collected Drosophilas and related forms on the River Campus of the University of Rochester at Rochester, New York. One of the commonest types to be found in the fermented banana traps used in the collections was a form identified as *Drosophila melanica* Sturtevant (1916). From June 5 through August 25 there were gotten 1263 individuals of this species, 538 of which were females, 725 males. In a recent paper Patterson (1942) has indicated that *D. melanica* should be divided into two subspecies, *melanica* and *paramelanica*, differing in distribution, *melanica* having been found in the southeastern United States and in Mexico, *paramelanica* occurring in the northeastern part of this country. It is probable, on the basis of locality, that the *D. melanica* individuals collected at Rochester belonged to the subspecies *paramelanica*. Towards the end of the collecting period, from August 19 through August 25, there occurred in the traps some male Drosophilas that seemed to differ from the *D. melanica* males only in the unusually dark pigmentation of their genital region. Altogether there were 10 such males collected. Since it was suspected that these males represented a new form, a number of apparently *D. melanica* females collected at the time were isolated individually into culture bottles in the hope that some of them would have offspring, males of which would be of this new type. Unfortunately, none of the females so isolated bred. Since it seemed unlikely that the females would have any progeny if left to themselves, an attempt was made to mate them to some of the *melanica*-like males. Culture bottles that had contained one of the females with two such males yielded some offspring. The male progeny were all of the new type in that their genital

* This study was begun while the author was holding a teaching assistantship at the University of Rochester, Rochester, New York.

region was darkly pigmented. These offspring proved to be fertile, and through allowing them to mate among themselves a strain was derived. Males of succeeding generations have all persisted in differing from *D. melanica* males in the dark pigmentation of the genital region. On the basis of this constant character of difference, as well as because of others noted below, the *melanica*-like form collected at Rochester is here designated a separate species, *Drosophila melanura*. A description of the new species is given next, with notes on comparison of the new form with *D. melanica* following just afterwards.

Description of the Species

Drosophila melanura, sp. nov.

EXTERNAL CHARACTERS OF IMAGINES.

♂ Arista with about 9 branches. Antennæ brownish, pollinose. Front blackish. Middle orbital length about ⅓ that of posterior one. Second oral length about ⅓ that of first. Carina broad below, sulcate. Face brownish. Cheeks pale brownish, about ⅙ greatest diameter of eye at their greatest width. Eyes red, with black pile.

Acrostichal hairs in irregular rows; about six rows at the anterior dorsocentral bristles. Anterior scutellars convergent. Mesonotum dull brown, with four slightly paler longitudinal stripes, two extending forward from just inside anterior dorsocentral bristles, two lying just outside the lateral pairs of dorsocentral bristles. Pleuræ brownish. Sterno-index about 0.9. Legs pale brownish. Two apical bristles on first tibiæ, one on second; preapicals on all three.

Broad, brown bands on abdominal segments 2 through 6, with posteriorly narrowing median interruptions, with but little interruption near the lateral margins of the tergites. Genital region (genital arch, anal plates, claspers, penis apparatus) dark brown.

Wings clear, veins brown. Costal index about 2.9; 4th vein index about 1.4; 5x index about 0.9; 4c index about 0.6. Two bristles at apex of first costal section. Third costal section with bristles on its basal ⅓.

Body length about 3.3 mm. (alive); wings 2.8 mm.

♀ Broad, brown bands on abdominal segments 2 through 6, with posteriorly narrowing median interruptions, often with wide lateral interruptions on the 6th segment.

Body length about 3.5 mm. (alive); wings 3.0 mm.

INTERNAL CHARACTERS OF IMAGINES.

Testis with about 3 inner coils (probably the seminal vesicle) and 3 outer ones, the coiled portion tending to be orange. Ejaculatory sac with 4 long diverticula, 2 anterior and 2 posterior.

Spermathecæ chitinized. Ventral receptacle with about 30 coils.

Additional notes.

EGG.—With 2 filaments, each about $\frac{2}{3}$ the length of the egg.

PUPARIUM.—Amber. About 9 branches in each anterior spiracle. Horn index (length of puparium/length of anterior spiracle horn) about 12.

CHROMOSOMES.—Female metaphase plate contains: one pair of large V's, two pairs of rods, one pair of medium V's, and one pair of small V's. Male metaphase plate has a J in place of one of the large V's.

KEY POSITION.—The following is to be taken as an expansion of the first line of couplet 50 of the Key to North American Species of Drosophila of Sturtevant (1942), to which point an attempt to classify a specimen of *D. melanura* should lead one.

50a.	Male genital region dark brown	*melanura*
	Male genital region not dark brown	*melanica*

DISTRIBUTION.—This species has been collected only in a small wood on the campus of the University of Rochester (River Campus), Rochester, New York.

Type specimens of *D. melanura* are deposited in the American Museum of Natural History, New York, N. Y.

Comparison with *D. melanica*

Drosophila melanura has been compared with individuals taken from *D. melanica* strains kept in this laboratory. These strains have been classified as to subspecies (*melanica* or *paramelanica*) by Prof. A. H. Sturtevant. The above description of *D. melanura*, as well as the notes which follow, is based largely on individuals of the single existing strain of this species, derived as indicated in the first paragraph.

The impression has been gotten that *D. melanura* is a larger form than *D. melanica.* This has been gotten not so much from wild individuals as from flies raised in the laboratory (the size measurements given in the above description were taken from "average" laboratory individuals). The difference in size may be partly due to the fact that the new species has not bred as vigorously in the laboratory as has *D. melanica* and has usually had the advantage of relatively uncrowded culture bottles.

D. melanura has also seemed to have a lighter body color than *D. melanica.* This difference is especially noticeable on the dorsal surface of the thorax, which may be described as medium brown in the new form, dark brown or very dark brown in *D. melanica.* Accompanying this difference is a greater prominence of the mesonotal stripes in *melanura* than in *D. melanica.* It is the impression of the author that the *D. melanica* subspecies tend to differ from each other in that *melanica* is somewhat darker than *paramelanica.* The thorax color difference between *melanura* and *D. melanica melanica* has been quite striking. Since a body color difference was not appreciated at the time the collections of *melanura* and *D. melanica* (probably *paramelanica*) were being made, the separation of wild females on the basis of color was not attempted. It remains to be seen how reliable a criterion this is for the identification of wild individuals in general.

The abdominal banding pattern of *D. melanura* males was found to be different from that of the *D. melanica* males examined. Whereas in *melanura* males the band on the 6th segment (as well as the others) was always found to be complete laterally, this was never seen to be the case in *D. melanica* males. In a *D. melanica* strain (*paramelanica*) from South Amherst, Massachusetts, the males' abdominal bands were all found to become indistinct near the lateral margins of the tergites. In a *D. melanica* strain (*melanica*) from Walnut Creek, Texas, while the bands on the 2nd through 5th abdominal segments generally extended all the way to the edges to the tergites, the band on the 6th segment was interrupted laterally.

Mention has already been made of the darkly pigmented genital region of males of the new species. This seems to be the best character whereby it may be recognized as different from *D. melanica.* In *D. melanura* males the genital arch, anal plates, and claspers become dark brown a few days after emergence. The plates of the penis apparatus also become dark. The result is that the genital region stands out conspicuously against the light ventral abdominal wall. In *D. melanica* the male genital region seems relatively inconspicuous.

In *D. melanura* and in *D. melanica* the penis apparatus apparently consists of two rather broad lateral plates as well as the

structure probably homologous to the chitinous rod called the penis by some authors (for example, Nonidez, 1920, in *D. melanogaster*). The appearance of the lateral plates was found to

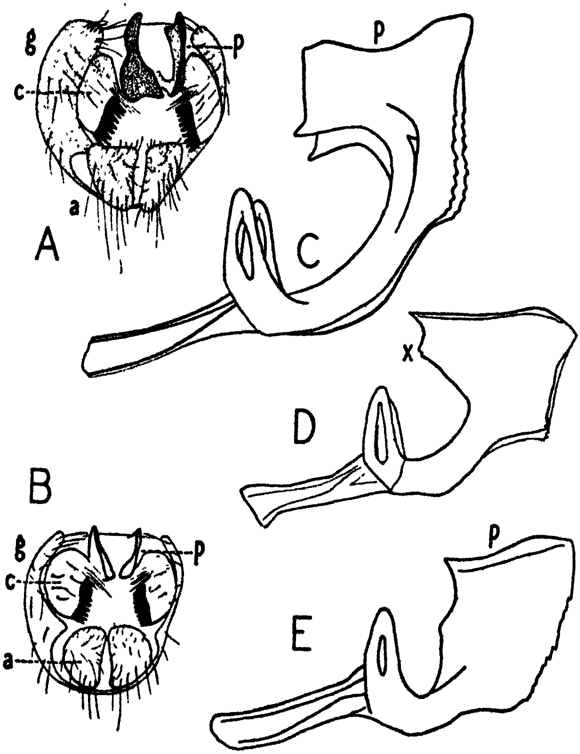

FIG. 1. A. Male genital region of *D. melanura*. B. Male genital region of *D. melanica paramelanica* (South Amherst, Mass.). The labels indicate: the anal plates (a), claspers (c), genital arch (g), and penis apparatus (p). These drawings were made from dead specimens, and the penis apparatus is shown farther forward than its usual position in living, etherized individuals. C. Penis apparatus of *D. melanura*. D. Penis apparatus of *D. melanica melanica* (Walnut Creek, Texas). E. Penis apparatus of *D. melanica paramelanica* (South Amherst). C, D, and E are side view drawings made on a somewhat larger scale than A and B. The edges labelled with a "p" in C and E correspond to the edges so labelled in A and B respectively. The point labelled with an "x" in D was found to vary somewhat in prominence.

differ between *melanura* and *D. melanica*. In *melanura* they were deeply incised at the anterior edge (Figure 1, C), whereas

in *D. melanica* they were not so much or scarcely at all so incised (Fig. 1, D & E). The structure of the plates in *D. melanica melanica* strains examined (Walnut Creek, Texas; Coffeeville, Kansas; Taneycomo, Missouri) seemed intermediate (Fig. 1, D) between that of *D. melanura* (Fig. 1, C) and that of *D. melanica paramelanica* strains (Madison, Wisconsin; South Amherst, Massachusetts) (Fig. 1, E). In *D. melanura* the impression was gotten that the penis apparatus is somewhat larger and more conspicuous relative to its surroundings than in *D. melanica* (Fig. 1, A & B).

The anterior spiracle horns of the puparium were found to be relatively shorter in *D. melanura* than in *D. melanica.* The horn index (length of puparium/length of horn) was determined to be about 12 in melanura, whereas *melanica* estimates were 9 for the South Amherst strain (*paramelanica*) and 7 for the one from Walnut Creek (*melanica*).

The chromosomes of *D. melanura* were investigated by means of acetic orcein smear preparations of larval ganglia and of ovaries and testes taken from pupæ and adults (using the 70 per cent acetic acid stain of LaCour, 1941). Examples of chromosome groups are given in Figure 2, A, B, and C. It may be seen that the smallest chromosome is not dot-shaped, as was reported in *D. melanica* by Metz (1916), but, rather, a small V. An investigation of *D. melanica* chromosomes, both *paramelanica* (South Amherst and Madison) and *melanica* (Walnut Creek), has confirmed Metz' report of dot-like chromosomes in this species (Figure 2, D, E, and F). Of interest here is the statement of Griffen (1942) that the *melanica* group species *D. nigromelanica* Patterson and Wheeler (1942) has rod-shaped microchromosomes rather than dots. The salivary gland chromosomes of *D. melanura* have not been studied.

As may be seen from the first paragraph of this paper *D. melanura* males were gotten in the summer, 1941, collections at Rochester in a much smaller number than were *D. melanica* males. Moreover, *D. melanura* was only collected past the middle of summer, late in August, while *D. melanica* occurred in the traps by early June. An ecological difference between the two species is suggested. *D. nigromelanica* was collected also

and had an occurrence in the traps similar to that of *D. melanura;* from July 26 to August 25 there were gotten 26 individuals of this species, 11 of which were males. A record of the collections of these *melanica* group species is given in Table 1.

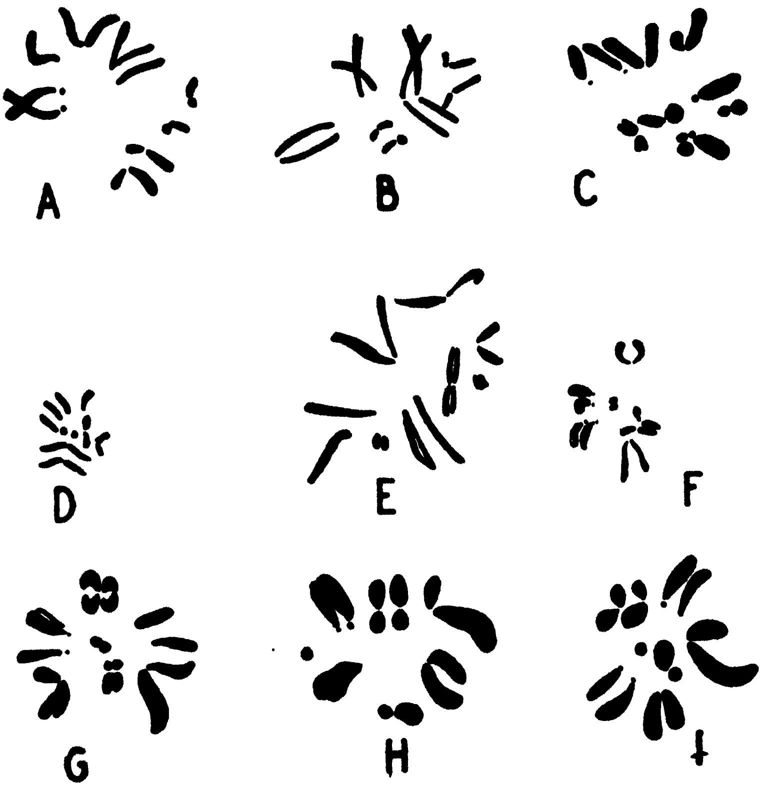

FIG. 2. A and B. *D. melanura* ovary metaphase figures. C. *D. melanura* testis metaphase. D and E. *D. melanica paramelanica* (South Amherst) ovary metaphases. In E some of the chromosomes, including the dot-like ones, are obviously split. F. *D. melanica melanica* (Walnut Creek) testis metaphase. The dots are close together. G, H, and I. Metaphase figures found in the testes of hybrids derived from *melanica* (Walnut Creek) females mated to *melanura* males.

D. melanura has been kept with some difficulty on the Drosophila culture media in use at this laboratory. The impression has been gotten that *D. melanica* has not been so difficult to main-

tain. In December, 1941, our corn meal-molasses-agar medium was changed in that agar was omitted from it and rolled oats were added (formula of Dr. R. H. MacKnight). The result has been a somewhat softer, wetter medium. From soon after the

TABLE 1. Week-by-week record of *melanica* group species collections at Rochester, New York, during the summer of 1941. The number of *D. melanura* females gotten is not recorded; these were most probably all classified as *D. melanica* females. Since the circumstances of collection (number of traps, number of collections, etc.) varied from week to week, the variation in absolute numbers should not be taken to reflect very well the changing state of the wild population.

		Collections for the week beginning:				
		June 1	June 8	June 15	June 22	June 29
melanica	♂♂			5	18	40
	♀♀	2	3	3	26	41
nigromelanica						
melanura						
		July 6	July 13	July 20	July 27	Aug. 3
melanica	♂♂	171	47	74	134	115
	♀♀	111	19	38	125	93
nigromelanica	♂	..	.	...	. .	1
	♀♀	. ..	..	1	1	6
melanura						
		Aug. 10	Aug. 17	Aug. 24	Total	Total
melanica	♂♂	46	57	18	725	
	♀♀	26	35	16	538	1263
nigromelanica	♂♂	7	3	.	11	
	♀♀	5		2	15	26
melanura	♂♂		7	3	10	10

change was made until about the middle of May, 1942, the *D. melanura* strain refused to breed at all. Following this period there has been a gradual recovery of ease of culture.

Hybrids with *D. melanica*

A few attempts were made to cross *D. melanica* females with *D. melanura* males, several individuals of a kind being used in each mating. Progeny have been gotten both from crosses of *melanica* (Walnut Creek) females by *melanura* males and from *paramelanica* (Madison) females by *melanura* males (Table 2).

A few matings were also made between *D. nigromelanica* females and *melanura* males, using a Harden County, Texas, strain furnished by Prof. J. T. Patterson, but no progeny were gotten (Table 2).

In general the interspecific cross progeny have been not very different from the maternal species. The penis apparatus of the

TABLE 2. Interspecific crosses involving *D. melanura.* The flies were put into fresh culture bottles on the dates listed under each mating. The numbers of progeny are placed opposite the dates appropriate to the bottles in which they occurred.

Cross	Progeny		
	♀♀	♂♂	Totals
D. melanica melanica ♀♀ × *D. melanura* ♂♂			
Walnut Creek ♀♀ × Rochester ♂♂ (7 of each)			
8– 7–42			
8–10–42			
8–15–42			
Walnut Creek ♀♀ × Rochester ♂♂ (22 of each)			
8– 8–42			
8–11–42	15	18	
8–15–42	7	7	
	22	25	47
Walnut Creek ♀♀ × Rochester ♂♂ (15 of each)			
8–10–42			
8–15–42	20	15	
8–19–42	40	35	
8–24–42	7	6	
8–31–42	46	31	
9– 8–42	24	24	
	137	111	248
D. melanica paramelanica ♀♀ × *D. melanura* ♂♂			
Madison ♀♀ × Rochester ♂♂ (5 of each)			
8– 8–42			
8–11–42			
8–15–42			
Madison ♀♀ × Rochester ♂♂ (7 of each)			
8–10–42			
8–15–42			
8–19–42			

TABLE 2—(*Continued*)

Cross	Progeny		
	♀♀	♂♂	Totals
D. melanica paramelanica ♀♀ × *D. melanura* ♂♂ (cont.)			
Madison ♀♀ × Rochester ♂♂ (15 of each)			
8– 7–42			
8–10–42			
8–15–42	6	6	
8–24–42	18	16	
8–31–42	5	4	
9– 8–42	.	1	
	29	27	56
D. nigromelanica ♀♀ × *D. melanura* ♂♂			
Harden Co. ♀♀ × Rochester ♂♂ (8 of each)			
9– 8–42			
9–12–42			
Harden Co. ♀♀ × Rochester ♂♂ (4 of each)			
9–1–42			
9–4–42			
9–8–42			
Harden Co. ♀♀ × Rochester ♂♂ (13 of each)			
9– 4–42			
9– 8–42			
9–10–42			

hybrid males, for example, has been rather similar to that of males of the form to which the mother belonged. Both sexes have seemed quite viable, and the sex ratio has been about 1 to 1 (Table 2).

Metaphase plates found in the testes of hybrid males derived from both the kinds of crosses mentioned above contained one dot-like chromosome and one small V (Fig. 2, G, H, and I). This evidence may be offered as one form of proof of the hybrid nature of these offspring. The salivary gland chromosomes of several larvæ were looked at, and although a very careful study of these chromosomes was not made, it did seem likely that they were heterozygous for a number of chromosomal rearrangements, probably inversions.

TABLE 3. Backcrosses of hybrid females to *D. melanura* and to *D. melanica*.

Cross	Progeny		
	♀♀	♂♂	Totals
(*melanica* ♀♀ × *melanura*) ♀♀ × *D. melanura* ♂♂			
(W. C. ♀♀ × Roch.) ♀♀ × Rochester ♂♂ (13 of each)			
8–31–42			
9– 3–42			
9– 8–42			
(W. C. ♀♀ × Roch.) ♀♀ × Rochester ♂♂ (7 of each)			
9–1–42			
9–4–42			
9–8–42			
(*paramelanica* ♀♀ × *melanura*) ♀♀ × *D. melanura* ♂♂			
(Mad. ♀♀ × Roch.) ♀♀ × Rochester ♂♂ (2 of each)			
9– 4–42			
9– 8–42			
9–10–42			
(*melanica* ♀♀ × *melanura*) ♀♀ × *D. melanica melanica* ♂♂			
(W. C. ♀♀ × Roch.) ♀♀ × Walnut Creek ♂♂ (17 of each)			
9– 4–42			
9– 8–42			
9–10–42	45	30	
9–18–42	26	15	
9–25–42	31	20	
	102	65	167
(*paramelanica* ♀♀ × *melanura*) ♀♀ × *paramelanica* ♂♂			
(Mad. ♀♀ × Roch.) ♀♀ × Madison ♂♂ (9 of each)			
9–30–42			
10– 3–42			
10– 8–42			

No offspring have been gotten from hybrid males and females kept together. It seems likely that the males are sterile. Although hybrid testes were found to contain many sperms, no motility of these sperms in Ringers' solution was seen. Moreover, acetic orcein smears have shown these testes to contain a number of rather large, spindle-shaped, dully-staining bodies, but no regular sperm heads. It is probable that these elongate structures are the product of an abnormal spermiogenesis.

Attempts have been made to backcross hybrid females both to *D. melanura* and to *D. melanica* males, and offspring were gotten in the case of a group mating of hybrid females (Walnut Creek ♀♀ × Rochester ♂♂) to Walnut Creek males (*melanica*) (Table 3). A rather obvious excess of females over males may be seen in these progeny. Since no mutants were involved in the crosses that gave rise to them, little could be concluded about the genetic constitution of the back-cross individuals. Some of the males were dissected 10 or 11 days after emergence and their testes examined. Out of 20 such males 2 had testes containing small, pyknotic bodies of various shapes, but no normal sperm heads, while the others had normal appearing sperms. Several recently hatched males were dissected and their testes examined for chromosome groups. In one of the testes there were found rather clear figures showing the presence of a dot and small V together, and in this testis there were a number of quite normal appearing sperm heads.

SUMMARY

Drosophila melanura, a new species similar to *D. melanica* Sturt., is described here. Notes on comparison of the two forms are presented. These species differ cytologically in the appearance of the smallest chromosome in the metaphase plate, *D. melanura* having a small V where *D. melanica* has a dot. Hybrids have been obtained from crosses between *D. melanura* females and *D. melanica* males, and the female hybrids have proved to be fertile.

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LITERATURE CITED

GRIFFEN, A. B. 1942. Relationships in the Melanica Species Group. Univ. of Texas Publ., 4228: 68–73.

LACOUR, L. 1941. Acetic-orcein: A New Stain-fixative for Chromosomes. Stain Techn., 16: 169–174.

METZ, C. W. 1916. Chromosome Studies on the Diptera. III. Additional Types of Chromosome Groups in the Drosophilidæ. Amer. Nat., 50: 587–599.

NONIDEZ, J. F. 1920. The Internal Phenomena of Reproduction in Drosophila. Biol. Bull., 39: 207–230.

PATTERSON, J. T. 1942. Interspecific Hybridization in the Genus Drosophila. Univ. of Texas Publ., 4228: 7–15.

——— and M. R. WHEELER. 1942. Description of New Species of the Subgenera Hirtodrosophila and Drosophila. Univ. of Texas Publ., 4213: 67–109.

STURTEVANT, A. H. 1916. Notes on North American Drosophilidæ with Descriptions of Twenty-three New Species. Ann. Ent. Soc. Amer., 9: 323–343.

———. 1942. The Classification of the Genus Drosophila, with Descriptions of Nine New Species. Univ. of Texas Publ., 4213: 5–51.

NOTES ON MEXICAN BUTTERFLIES, II, PIERIDÆ

BY F. MARTIN BROWN

The collections made by Hoogstraal's parties and by Potts contained 33 of the 71 species of Pieridæ reported by Hoffmann. Those lacking are primarily the truly tropical species that enter Chiapas and the southern lowlands and some of the western Nearctic things that are found in Sonora and Baja California. I have added the data from a small collection made by H. D. Thomas in 1936.

Several localities not mentioned in the first paper on the Papilionidæ (*q.v.*)* are noted here:

GEOGRAPHIC DATA

Acahuato, Michoacan, 19° 20′ N., 102° 20′ W., 3000 ft.

"On the edge of the plateau above Apatzingan. Open semi-desert with scattered trees below the town and open pine forest above it. Transitional between the tropics and temperate area." *Hoogstraal.*

Cumbres, Vera Cruz, 6000 ft., km. 295 on road to Vera Cruz from Mexico City.

"North and west of Orizaba, very definitely up and out of the tropical zone and rain belt, into a dry upland type of country even though still the bottom of the valley. A lot of straggling thorn bush, tremendous organ cactus, a lot of *Opuntia.* Short grass and rock slopes. Temp. at about 75 or less." *Potts.*

El Mante, San Luis Potosi.

"A strange conglomeration in this region of swampy country with tall palms and very tall thorn bush jungle next to bananas, corn fields and maguey. Cactus growing in mud! Temp. probably 95° F." *Potts.*

Hda. Potrero Viejo, nr. Paraje Nuevo, Vera Cruz.

"Cultivated country for centuries, yet plenty of original vegetation nearby. I collected only in a small meadow near the

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hacienda itself." *Potts.* Between Fortin and Orizaba on the Mexico City-Vera Cruz highway.

Hda. Santa Engracia, Tamaulipas.
I have no data on this station. *F.M.B.*

Monte Alban, Oaxaca, 16° 50′ N., 96° 20′ W., 6000 ft.
"Hills back of Oaxaca, the only moist country nearby!" *Potts.*

Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 26° 40′ N., 100° 15′ W., 1000–1600 ft.
"Collections were made up to 1600 ft., low shrubs and cactus." *Hoogstraal.*

Orizaba, Vera Cruz, 18° 45′ N., 96° 50′ W., 2200 ft.
"About a kilometer SE. of the town. Just the top end of the tropics or at least the jungle tropics, along the valley slope. Impenetrable underbrush, lush, rains some 9 or 10 months of the year here." *Potts.*

Sta. Lucrecia.
A Thomas station which must be on the west coast, probably in Michoacan, from the material so labeled. *F.M.B.*

Rio Balsas, Guerrero, 18° ± S., 98°–102° W.
The great river basin of southern Mexico. "The river itself is pretty dry. Collected up a side canyon to the south. Temp. 105–110, muggy. Thorn bush and rocks." *Potts.* The collection was made near Mexcala (18° 0′ S., 99° 30′ W., 2400 ft.).

Tuxpango, Vera Cruz, ? 1500 ft.
"Top of a big wide barranca SE. of Orizaba. County similar to 'Orizaba.'" *Potts.*

Dismorphiinæ

I am surprised that these two collectors, Hoogstraal and Potts, were so unsuccessful in finding members of this sub-family. At least nine species are known from the areas they visited. Only Hoogstraal collected any and his material represents one species.

61. **Enantia jethys** Boisduval.

G. & S. (1), **2**: p. 182–183, 727, pl. 61, f. 56; pl. 74, f. 27, 28 (as *albania*).

R. (2), p. 100.

H. (3), p. 654–5.

Tancitaro, Michoacan, 6600 ft. 3 ♂♂ 2 ♀♀ vii.20–viii.14.40 (H.H.).

Hoffmann, p. 654–5, recognizes three species, *citronella* Felder (1861), *jethys* Bdv. (1836) and *mita* Reak (1866). I feel that these represent but one variable species. I have a long series of specimens from various tropical stations and among them are all intergrades from *jethys* to *citronella* to *mita*. Whether these are in turn only varieties of *melite* Linnæus or not I am not sure. The most heavily marked specimen should be referred to f. *jethys* Bdv., those without the dark bar along the inner margin of the forewing to f. *citronella* Felder, and those with further restriction of the dark apical markings to f. *mita*.

The specimens noted above are of f. *citronella*. I suspect that the degree to which the dark markings are developed is related to the season or moisture, the darkly marked individual being "wet season" the lightly marked, "dry season."

63. **Enantia marion,** Godman & Salvin.

G. & S., **2**: 184.

R., p. 100.

H., p. 655.

El Sabino, Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

Pierinæ

(Euchloini)

72. **Hesperocharis costaricensis** Bates.

G. & S., **2**: 126, pl. 60, f. 3, 4.

R., p. 79, pl. 23f.

H., p. 656.

Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.).

El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).

Apparently this is the first record of the species from the east coast of Mexico. Hoffmann, p. 656, reports the species from the west coast of Guerrero, Michoacan, Jalisco and Colima.

(Rhodocerini)

74. **Colias eurytheme** Boisduval.

G. & S., **2**: 151 (as *chrysotheme*).

R., p. 93, pl. 27f.

H., p. 656.

Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 2 ♀♀ vi.17.40 (H.H.).

Galeana, Nuevo Leon, 6500 ft., 1 ♂ vii.30.39 (H.H.).

Tancitaro, Michoacan, 6600 ft., 1 ♂ viii.11.40 (H.H.).

These few specimens do not indicate the abundance of the species in Mexico. It is probable that the species was ignored in most localities. The Nuevo Leon material is f. *amphidusa* Bdv., the other is typical of f. *eurytheme*.

77. **Zerene cæsonia** Stoll.

G. & S., **2**: 153, 727 (as *cesonia*).

R., p. 94, pl. 26f.

H., p. 656.

Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 4 ♂♂ 1 ♀ vi.16–18.40 (H.H.).

Arroyo del Meco, Tamaulipas, 1320 ft., 1 ♂ iv.28.41 (R.P.).

Jacala, Hidalgo, 4500 ft., 7 ♂♂ 1 ♀ vi.25–vii.1.39 (H.H.).

El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♂ vi. 28.40 (H.H.).

Tancitaro, Michoacan, 6600 ft., 1 ♀ vii.30.40 (H.H.).

Apatzingan, Michoacan, 1050 ft., 1 ♂ vii.5.40 (H.H.).

Rio Balsas, Guerrero, 2400 ft., 1 ♀ v.26.41 (R.P.).

Chilpancingo, Guerrero, 1 ♀ v.26.41 (R.P.).

The specimens are all in a condition indicating recent emergence.

78. **Anteos clorinde** Godart.

G. & S., **2**: 148, 726.

R., p. 89, pl. 24g.

H., p. 656.
Victoria, Tamaulipas, 1 ♂ vi.25.35 (H. A. Freeman).
El Pujal, San Luis Potosi, 100 ft., 16 ♂♂ vii.17.39 (H.H.).
Arroyo del Calabezas, San Luis Potosi, 250 ft., 2 ♂♂ iv.30.41 (R.P.).
Hda. Potrero Viejo, nr. Parare Nuevo, Vera Cruz., 1500 ft., 1 ♂ v.5.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 3 ♂♂ vi.24–vii.7.39 (H.H.).
Apatzingan, Michoacan, 1 ♀ viii.2.40 (H.H.).

The Apatzingan ♀ is badly rubbed, but appears to lack the usual large yellow area on the forewing.

79. **Anteos mærula** Fabricius.
G. & S., **2**: 149, 726.
R., p. 89, pl. 24g.
H., p. 656.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 2 ♂♂ vi.17–18.40 (H.H.).
Victoria, Tamaulipas, 1 ♂ vi.25.35 (H. A. Freeman).
60 mi. S. of Victoria, Tamaulipas, 1 ♂ vii.6.36 (H.D.T.).
El Bañito, Valles, San Luis Potosi, 200 ft., 4 ♂♂ 2 ♀♀ vi.26.40 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 12 ♂♂ vii.17.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 150 ft., 1 ♂ 1 ♀ v.29.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 3 ♂♂ vii.1–10.39 (H.H.).
Chichen Itza, Yucatan, 1 ♂ iv.7.36 (F.M.B.).

The females from El Bañito are f. *gueneeana* Bdv., the one from El Sol is the nymotypical form.

80. **Phoebis sennæ** Linnæus.
G. & S., **2**: 141 (as *eubule*).
R., p. 85.
H., p. 657.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 3 ♂♂ 1 ♀ vi.16–21.40 (H.H.).

Hda. Santa Engracia, Tamaulipas, 2 ♂♂ vii.27.39 (H.H.).

El Bañito, Valles, San Luis Potosi, 400 ft., 2 ♂♂ 1 ♀ vi.26–28.40 (H.H.).

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ 1 ♀ v.29.41 (R.P.).

Jacala, Hidalgo, 4500 ft., 3 ♂♂ vi.29.39 (H.H.).

Chichen Itza, Yucatan, 1 ♀ iv.8.36 (F.M.B.); 1 ♀ viii.30.36 (H.D.T.).

Sta. Lucrecia, 1 ♂ ix.24.39 (H.D.T.).

Apatzingan, Michoacan, 1200 ft., 2 ♂♂ 1 ♀ viii.3–5.40 (H.H.).

El Sabino, Uruapan, Michoacan, 1 ♂ 1 ♀ vii.15–30.36 (H.D.T.).

Tancitaro, Michoacan, 4500 ft. 1 ♂ viii.11.41 (H.H.).

The males from Nuevo Leon are fairly typical of race *eubule* L. the others tend toward *marcellina* Cr., but none of them is as strongly marked as the typical males from tropical South America. It is a pity that no one bothers to collect this common species in sufficient numbers to settle the question of what race the Mexican material represents. I would designate all of the above males *eubule* f. *drya* Fabricius. I fully realize that elsewhere (*Amer. Mus. Nov.* 368, p. 7, 1929) I stated that Mexican material was referable to *marcellina* Cr. I also noted (p. 8) that the tropical race might well represent two races. The more material that I see from Mexico the more I feel that these statements need revising, but I have not the material to do so. It is quite probable that in Mexico the two races so intergrade that we have a continuous cline from *eubule* to *marcellina*.

The El Banito female is f. *pallida* Cockerell, the El Sol, *yamana* Reakirt. The Hda. Vista Hermosa female is a good *marcellina* Cr. The Apatzingan female is badly rubbed but is probably f. *yamana*. *F.M.B.'s* from Chichen Itza is *pallida* while *H.D.T.'s* is *marcellina*.

81. **Phoebis philea** Linnæus.

G. & S., **2**: 140, 726.

R., p. 86, pl. 25c.

H., p. 657.

El Pujal, San Luis Potosi, 100 ft., 2 ♂♂ vii.17.39 (H.H.). (H.H.).

Apatzingan, Michoacan, 1200 ft., 1 ♂ viii.5.40 (H.H.).

83. **Phoebis agarithe maxima** Neumoegen.

G. & S., **2**: 145, 726 (as *agarithe*).

R., p. 86 (as *argante agaritha*).

H., p .657.

Hda. Vista Hermosa, Nuevo Leon, 1500 ft., 6 ♂♂ 3 ♀♀ vi.16–21.40 (H.H.).

Sabinas Hidalgo, Nuevo Leon, 960 ft., 2 ♂♂ 2 ♀♀ vi.15–18.39 (H.H.).

Arroyo del Meco, Tamaulipas, 1320 ft., 2 ♂♂ iv.28.41 (R.P.).

Hda. Santa Engracia, Tamaulipas, 2 ♂♂ vii.25.39 (H.H.).

Victoria, Tamaulipas, 1 ♀ vi.28.35 (H. A. Freeman).

60 mi. S. Victoria, Tamaulipas, 1 ♀ vii.6.36 (H.D.T.).

El Pujal, San Luis Potosi, 100 ft., 3 ♂♂ vii.20–21.39 (H.H.).

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ v.29.41 (R.P.).

Tamazunchale, San Luis Potosi, 500 ft., 1 ♂ vi.30.40 (H.H.).

Arroyo del Calabezas, San Luis Potosi, 250 ft., 1 ♂ iv.30.41 (R.P.).

El Bañito, San Luis Potosi, 200 ft., 3 ♂♂ 1 ♀ { vii.22.39 (H.H.). vi.26.40 (H.H.).

El Mante, San Luis Potosi, 1 ♂ iv.29.41 (R.P.).

Orizaba, Vera Cruz, 2000 ft., 1 ♂ v.6.41 (R.P.).

These are all good *maxima* except the El Sol male which approaches *agarithe*. The northern specimens are absolutely typical, those from the south show some of the brownish markings on the underside. All the females are f. *albarithe* Brown.

83c. **Phoebis agarithe agarithe** Boisduval.

Progresso, Yucatan, 1 ♀ viii.27.36 (H.D.T.).

Chichen Itza, Yucatan, 1 ♀ viii.30.36 (H.D.T.).

These two females are much more like typical South American *agarithe* than *maxima* and I have so designated them. They are not *antillia* Brown, which might be expected on the peninsula. The Progresso specimen is the yellow form, the Chichen Itza one the white form. Hoffmann has not included this race in his check-list.

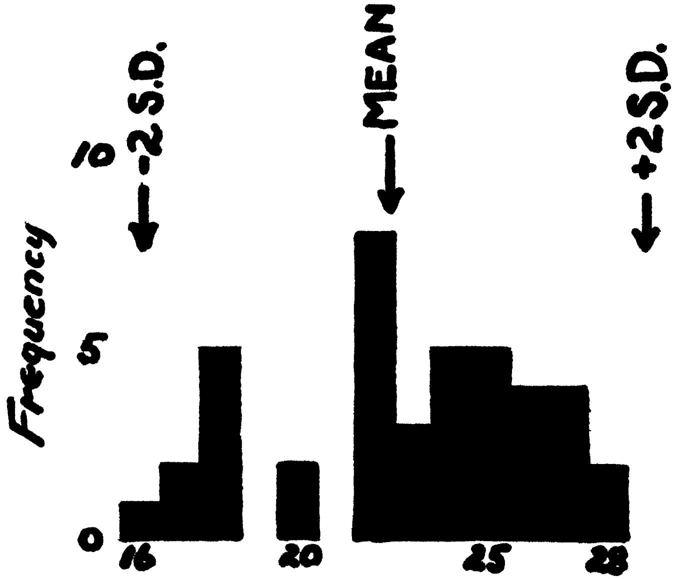
84. **Phoebis intermedia** Butler.
G. & S., **2**: 143, 726 (as *rurina*).
R., p. 86.
H., p. 657.
Tancitaro, Michoacan, 4500 ft., 1 ♂ vii.25.40 (H.H.).

86. **Aphrissa statira jada** Butler.
G. & S., **2**: 147 (as *statira*).
R., p. 87 (as *statira*).
H., p. 657.
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♀ vi.26.40 (H.H.).

This is a pale lemon yellow female like those of true *statira*.

87. **Kricogonia lyside** Godart.
G. & S., **2**: 150, 151, 726 (as *unicolor*).
R., p. 89.
H., p. 658.
Sabinas Hidalgo, Nuevo Leon, 900 ft., 9 ♂♂ 10 ♀♀ vi.15–18.39 (H.H.).
Ojo de Agua, Sabinas Hidalgo, N. L., 1000 ft., 2 ♂♂ vi.14.40 (H.H.).
Villa Santiago, Nuevo Leon, 1500 ft., 2 ♂♂ viii.8.39. (H.H.).
35 km. W. of Linares, Nuevo Leon, 1 ♀ viii.7.39. (H.H.).
Galeana, Nuevo Leon, 2 ♂♂ 2 ♀♀ vii.28–viii.4.39. (H.H.).
Hda. Sta. Engracia, Tamaulipas, 1 ♂ 1 ♀ vii.25–27.39 (H.H.).
El Bañito, Valles, San Luis Potosi, 1 ♀ vii.22.39 (H.H.).
nr. Apatzingan, Michoacan, 500 ft., 3 ♂♂ 3 ♀♀ viii.3.40 (H.H.).
Apatzingan, Michoacan, 1050 ft., 1 ♂ 2 ♀♀ viii.2–5.40 (H.H.).

El Sabino, Uruapan, Michoacan, 2 ♂♂ 1 ♀ vii.15–30.36 (H.D.T.).
Acahuato, Michoacan, 3000 ft., 1 ♀ viii.2.40 (H.H.).
Tancitaro, Michoacan, 6600 ft., 1 ♂ vii.20.40 (H.H.).



It is rather strange that Potts took no specimens of this common species. The above series contains examples of all of the named forms that occur in Mexico.

	typical	♂ *terrissa*	♀ *unicolor*	♀ *fantasia*
Nuevo Leon . .	21	5	4	1?
Tamaulipas .		1	1	..
San Luis Potosi .	1		.	.
Michoacan	7	3	1	4

The specimens noted as *fantasia* are not typical; they all lack the costal yellow streak and the ground color of the wings tends to be greenish rather than yellow. The size of the specimens varies greatly. This is best shown in the text figure, based upon the baso-apical radius of the forewings, and the following table of data.

	N.	Mean	S.D.	Critical limits	Range
Total series ...	45	21.37 ± 0.57 mm.	3.66 mm.	14.1 mm., 28.7 mm.	16–28 mm.
Sabinas Hidalgo	19	22.90 ± 0.34 mm.	3.27 mm.	16.5 mm., 29.4 mm.	16–28 mm.

88. **Eurema albula** Cramer.

G. & S., **2**: 166.
R., p. 84.
H. p. 658.
K. (4), p. 121.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 11 ♂♂ iv.30, v.29.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 4 ♂♂ v.12.41 (R.P.).
El Sabino, Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

Two of the Ojo de Agua specimens are intermediate to *albula* and f. *tapeina* Bates.

89. **Eurema jucunda** Boisduval.

G. & S., **2**: 168, pl. 64, f. 9–12.
R., p. 83, pl. 24e.
H., p. 658.
K., p. 124.
nr. Acapulco, Guerrero, 100 ft., 1 ♀ v.26.41 (R.P.).
nr. Chilpancingo, Guerrero, 4 ♂♂ 3 ♀♀ v.26.41 (R.P.).
Rio Balsas, Guerrero, 2400 ft., 1 ♀ v.26.41 (R.P.).
El Sabino, Uruapan, Michoacan, 10 ♂♂ 9 ♀♀ vii.15–30.36 (H.D.T.).
Apatzingan, Michoacan, 3000 ft., 1 ♂ viii.2.40 (H.H.).
Tancitaro, Michoacan, 6600 ft., 1 ♂ 1 ♀ vii.25, viii.11.40 (H.H.).

All the males are of f. *sidonia* Felder. This is also true of the females except for two from Chilpancingo which tend toward the typical in respect to the margin of the hindwings. The general color of the females varies from white to pale yellow. One of the Chilpancingo specimens and the one from Rio Balsas have white forewings and yellow hindwings.

89a. **Eurema jucunda lydia** Felder.

G. & S., **2**: 170, pl. 63, f. 20–23.
R., p. 83 (as *delia lydia*).
H., p. 658.
K., p. 126 (as *palmyra lydia*).
Jacala, Hidalgo, 4500 ft., 3 ♂♂ 2 ♀♀ vi.25–vii.2.39 (H.H.).

El Pujal, San Luis Potosi, 100 ft., 5 ♂♂ 2 ♀♀ vii.17–21.39 (H.H.).

Tuxpango, Vera Cruz, 1500 ft., 1 ♂ 2 ♀♀ v.9.41 (R.P.).

Hda. Potrero Viejo, Vera Cruz, 1500 ft., 1 ♂ 1 ♀ v.5.41 (R.P.).

Orizaba, Vera Cruz, 2000 ft., 4 ♂♂ 1 ♀ v.6.41 (R.P.).

Rio Blanco, Vera Cruz, 2200 ft., 2 ♂♂ 1 ♀ v.10.41 (R.P.).

This series of "barred" *Euremas* from the east coast is quite variable. All have the pearly white under surfaces characteristic of *jucunda*. The females are fairly constant, having a reduced grey bar on the inner margin of the forewing and an incomplete black margin on the hindwing. One Jacala specimen is faintly flushed with yellow on the forewing and the Rio Blanco female bears this flush on the hindwing. The males are extremely varied but I hesitate to refer the specimen to anything other than *lydia*. The marginal band of black on the hindwings is broad and complete on two (Rio Blanco and Orizaba), narrower but complete on two (El Pujal) and interrupted on the rest. In no case is the margin reduced to an apical spot. The hindwings range from yellow (♂ Jacala) to white with many specimens just faintly tinged with yellow. Until a lot of life history work is done and enormous series taken over long periods of time for many localities we will not be able to unravel the puzzle of the "barred" *Euremas*.

91. **Eurema boisduvaliana** Felder.

G. &. S., **2**: 159, pl. 63, f. 1–4.

R., p. 81 (as *mexicana*, in part).

H., p. 658.

K., p. 133.

Galeana, Nuevo Leon, 6500 ft., 1 ♂ 10.29.41 (R.P.).

Jacala, Hidalgo, 4500 ft., 4 ♂♂ 1 ♀?, vi.29–vii.5.39 (H.H.).

El Pujal, San Luis Potosi, 100 ft., 11 ♂♂ vii.12–21.39 (H.H.).

Arroyo del Calabezas, San Luis Potosi, 1 ♂ iv.30.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 1 ♂ 1 ♀ vi.26–27.40 (H.H.).

El Sol, Tamazunchale, San Luis Potosi, 2 ♂♂ v.29.41 (R.P.).
Fortin, Vera Cruz, 1600 ft., 2 ♂♂ v.4.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 1 ♂ v.4.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 8 ♂♂ v.10.41 (R.P.).
Chichen Itza, Yucatan, 1 ♂ viii.30.36 (H.D.T.).
El Sabino, Uruapan, Michoacan, 1 ♀?, vii.15–30.36 (H.D.T.).
Apatzingan, Michoacan, 3200 ft., 1 ♀ viii.2.40 (H.H.).

The questioned female from Jacala is aberrant. The apical patch on the hindwings is reduced to a few scales along the nervule. The same is true of the El Sabino female.

92. **Eurema xanthochlora** Kollar.
G. & S., **2**: 161, 727, pl. 63, f. 5–8.
R., p. 81, pl. 24b.
H., p. 658.
K., p. 134.
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♀ vi.28.40 (H.H.).
Tuxpango, Vera Cruz, 1500 ft., 1 ♂ v.9.41 (R.P.).

93. **Eurema mexicana mexicana** Boisduval.
G. & S., **2**: 157.
R., p. 81, pl. 24a.
H., p. 659.
K., p. 134.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500–3000 ft., 6 ♂♂ 1 ♀ vi.17–21.40 (H.H.).
Villa Santiago, Nuevo Leon, 1500 ft., 1 ♂ viii.8.39 (H.H.).
Jacala, Hidalgo, 4500 ft., 37 ♂♂ 1 ♀ vi.23–vii.2.39 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 1 ♂ vii.17.39 (H.H.).
El Sol, Tamazunchale, 400 ft., 8 ♂♂ v.28–29.41 (R.P.); 1 ♀ iv.31.41 (R.P.).
Tuxpango, Vera Cruz, 1500 ft., 1 ♀ v.8.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 5 ♂♂ v.10.41 (R.P.).
Cumbres (km. 295), Vera Cruz, 6000 ft., 1 ♂ v.7.41 (R.P.).

El Sabino, Uruapan, Michoacan, 3 ♂♂ vii.15–30.36 (H.D.T.).

Tancitaro, Michoacan, 6600 ft., 1 ♂ viii.14.40 (H.H.).

Cerro Tancitaro, Michoacan, 7000 ft., 2 ♂♂ vii.20.40 (H.H.).

All these specimens are typical *mexicana.* Hoffmann includes in his listing of the species both ab. *recta* Klots and ab. *biedermanni* Ehrmann with question marks. I have a distinct feeling that these two "aberrations" describe the material from the northern reaches of the race such as the mountains of Colorado and should be raised to racial status. Ehrmann's name is available for this. There is some variation in size among the specimens before me. A male from Villa Santiago measures only 15 mm. along the baso-apical radius of the forewing while the largest specimen from El Sol measures 27 mm. The black margin of the hindwing is variable; on some specimens it is a small patch anterior to M_2 while in others it extends to Cu_2. On these latter it is broadest at the M_2–M_3 interspaces and has a basad spur in M_3–Cu_1.

94. **Eurema salome** Felder.

G. & S., **2**: 160 (as *fabiola*).

R., p. 81.

H., p. 659.

K., p. 136.

Jacala, Hidalgo, 4500 ft., 16 ♂♂ vi.23–vii.2.39 (H.H.).

Fortin, Vera Cruz, 1600 ft., 1 ♂ v.3.41 (R.P.).

These are all f. *limoneus* Felder. I disagree with Hoffmann and agree with Klots on the status of this name. I feel that the species is splitting into two races and that the northern material from Mexico is sufficiently different from Ecuadorian *salome* to require a name in this genus.

95. **Pyristia gundlachia** Poey.

G. & S., **2**: 156.

R., p. 81, pl. 21a.

H., p. 659.

K., p. 137.

Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 2 ♀♀ vi.17–22.40 (H.H.).

96. **Pyristia proterpia** Fabricius.
G. & S., **2**: 155.
R., p. 81, pl. 24a.
H., p. 659.
K., p. 137.
nr. Villagran, Tamaulipas, 1160 ft., 1 ♂ iv.28.41 (R.P.).
C. Victoria, Tamaulipas, 1 ♂ vi.19.39 (H.H.).
Hda. Sta. Engracia, Tamaulipas, 1 ♂ vii.27.39 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 3 ♂♂ 1 ♀ vii.17–20.39 (H.H.).
Rio Blanco, Vera Cruz, 2200 ft., 2 ♂♂ v.10.41 (R.P.).
Chichen Itza, Yucatan, 1 ♂ viii.30.36 (H.D.T.).
Acapulco, Guerrero, 100 ft., 1 ♂ v.26.41 (R.P.).
Apatzingan, Michoacan, 1050 ft., 5 ♂♂ viii.2–5.40 (H.H.).
El Sabino, Uruapan, Michoacan, 10 ♂♂ 4 ♀♀ vii.15–30.36 (H.D.T.).
Tancitaro, Michoacan, 7000 ft., 1 ♂ 1 ♀ vi.25–30.40 (H.H.).

On the northernmost specimen (Villagran) the black markings are greatly reduced. The Chichen Itza specimen approaches *watsoni* from the similar arid area in Ecuador!

97. **Pyristia dina westwoodi** Boisduval.
G. & S., **2**: 163 (as *dina*).
R., p. 82, pl. 24b.
H., p. 659.
K., p. 139.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 7 ♂♂ 4 ♀♀ iv.30–31, v.28–29.41 (R.P.).
Arroyo del Calabezas, San Luis Potosi, 250 ft., 1 ♂ iv.30.41 (R.P.).
Chichen Itza, Yucatan, 1 ♂ viii.30.36 (H.D.T.); 1 ♀ iv.7.36 (F.M.B.).
N. of Iguala, Guerrero, 1 ♂ v.22.41 (R.P.).

All the females are much lighter than the males and in many respects, other than size, compare favorably with f. ♀ *citrina* Poey from the West Indies. The West Coast male is the exact counterpart of race *parvumbra* Kaye from Jamaica!

98. **Pyristia lisa euterpe** Ménètries.
G. & S., **2**: 162.
R., p. 83.
H., p. 659.
K., p. 138.
Sabinas Hidalgo, Nuevo Leon, 960 ft., 1 ♂ vi.15.39 (H.H.).
nr. Villagran, Tamaulipas, 1150 ft., 3 ♂♂ iv.28.41 (R.P.).
60 mi. So. of Victoria, Tamaulipas, 2 ♂♂ vii.6.36 (H.D.T.).
Jacala, Hidalgo, 4500 ft., 1 ♂ vii.6.39 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 1 ♀ vi.20.39 (H.H.).
Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.).

The female is f. *centralia* Herrick-Schaffer (*alba* Strecker).

99. **Pyristia nise perimede** Prittwitz.
G. & S., **2**: 165, 727 (as *tenella*).
R., p. 83, pl. 24d (as *nise*).
H., p. 659.
K., p. 140.
Sabinas Hidalgo, Nuevo Leon, 960 ft., 1 ♂ vi.31.39 (H.H.).
nr. Villagran, Tamaulipas, 1160 ft., 2 ♂♂ iv.28.41 (R.P.).
C. Victoria, Tamaulipas, 1 ♀ vi.19.39 (H.H.).
60 mi. So. of Victoria, Tamaulipas, 1 ♂ vii.6.36 (H.D.T.).
Hda. Sta. Engracia, Tamaulipas, 1 ♂ vii.25.39 (H.H.).
Jacala, Hidalgo, 4500 ft., 5 ♂♂ 2 ♀♀ vi.23–vii.2.39 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 3 ♀♀ vii.18–21.39 (H.H.).
Arroyo del Calabezas, San Luis Potosi, 250 ft., 1 ♂ iv.30.41 (R.P.). z
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ 1 ♀ v.28–29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 150 ft., 5 ♂♂ 2 ♀♀ vi.26.40, vii.22.39 (H.H.); iv.30.41 (R.P.).
Hda. Potrero Viejo, Paraje Nuevo, Vera Cruz, 1500 ft., 3 ♂♂ v.5.41 (R.P.).

Orizaba, Vera Cruz, 2000 ft., 2 ♂♂ v.6.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 8 ♂♂ v.10.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♀ v.12.41 (R.P.).
Acapulco, Guerrero, 100 ft., 1 ♂ v.23–25.41 (R.P.).
Sta. Lucrecia, 1 ♂ ix.24.39 (H.D.T.).
Apatzingan, Michoacan, 500 ft., 1 ♂ viii.3.40 (H.H.).
El Sabino, Uruapan, Michoacan, 5 ♂♂ 2 ♀♀ vii.15–30.36 (H.D.T.).

There is a great deal of variation in this series, none of it related to geographic distribution. The ground color varies from pale to deep lemon. The dark margin on the hindwings varies from complete to absent; on over half of the specimens it is represented by only a row of black dots on the nervules. There is some variation in the extent of the black marking on the forewing. On some the underside is boldly marked; on others it is almost immaculate.

100. **Abæis nicippe** Cramer.
G. & S., **2**: 155, 727.
R., p. 81, pl. 24a.
K., p. 132.
H., p. 659.
Sabinas Hidalgo, Nuevo Leon, 960 ft., 5 ♂♂ vi.15–16.39 (H.H.).
Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 1300 ft., 1 ♂ vi.14.40 (H.H.).
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 1 ♂ 2 ♀♀ vi.16–21.40 (H.H.).
Galeana, Nuevo Leon, 6500 ft., 2 ♂♂ vii.30–viii.3.39 (H.H.).
Jacala, Hidalgo, 4500 ft., 11 ♂♂ vi.23–vii.2.39 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 1 ♂ n.d. (H.H.).
Hda. Potrero Viejo, nr. Paraje Nuevo, Vera Cruz, 1500 ft., 1 ♂ vi.5.41 (R.P.).
Monte Alban, Oaxaca, 6000 ft., 1 ♂ v.18.41 (R.P.).

The Monte Alban specimen is notable for the reduction of the dark apical markings on it.

101. **Nathalis iole** Boisduval.
G. & S., **2**: 172, pl. 64, ff. 15–18.

R., p. 95, pl. 27h (as *jole*).
H., p. 659.
bet. Adjuntas & Sabinas Hidalgo, Nuevo Leon, 3000 ft., 1 ♂ vi.21.40 (H.H.).
Sabinas Hidalgo, Nuevo Leon, 1500 ft., 1 ♂ 1 ♀ vi.17.40 (H.H.).
Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 1000 ft., 1 ♂ vi.15.40 (H.H.).
Galeana, Nuevo Leon, 6500 ft., 1 ♂ vii.30.39 (H.H.).
nr. Villagran, Tamaulipas, 1160 ft., 1 ♂ iv.28.41 (R.P.).
C. Victoria, Tamaulipas, 1 ♀ vi.19.39 (H.H.).
60 mi. So. of Victoria, Tamaulipas, 1 ♀ vii.6.36 (H.D.T.).
Jacala, Hidalgo, 4500 ft., 10 ♂♂ 1 ♀ vi.23–vii.1.39. (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ v.29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 150 ft., 2 ♂♂ iv.30.41 (R.P.).
El Pujal, San Luis Potosi, 100 ft., 1 ♂ 1 ♀ vii.17.39 (H.H.).
Tuxpango, Vera Cruz, 1500 ft., 2 ♂♂ v.9.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 1 ♂ 1 ♀ v.6.41 (R.P.).
Cumbres (km. 295), Vera Cruz, 8000 ft., 3 ♂♂ v.7.41 (R.P.).
Monte Alban, Oaxaca, 6000 ft., 1 ♀ v.18.41 (R.P.).

The females from all localities other than Jacala and Monte Alban are f. *irene* Fitch. One of the Jalaca males has the forewing bar reduced to a submarginal spot.

(Pierini)

103. **Neophasia terlootii** Behr.
R., p. 55, pl. 18a.
H., p. 660.
Cerro Tancitaro, Michoacan, 5500 ft., 1 ♂ viii.17.40 (H.H.).

This capture of Hoogstraal's extends the range of this species over 300 miles southward. I suspect that it will be recovered still

further south, possibly in Central America in the pine-oak forests of Guatemala and Honduras.

104. **Catasticta flisa** Herrick-Schaffer.

G. & S., **2**: 117.
R., p. 73, pl. 22e.
H., p. 660.
Jacala, Hidalgo, 4500 ft., 1 ♂ vi.29.39 (H.H.).

This extends the range of the species northward from Vera Cruz (see H., p. 660).

105. **Catasticta nimbice nimbice** Boisduval.

G. & S., **2**: 118.
R., p. 70, pl. 22b.
H., p. 660.
Jacala, Hidalgo, 4500 ft., 2 ♂♂ vi.24–28.39 (H.H.).
Tancitaro, Michoacan, 6600 ft., 1 ♀ vii.30.40 (H.H.).

The female is freshly emerged, the males are worn.

110. **Appius ilaire** Godart.

G. & S., **2**: 135 (as *margarita*).
R., p. 59, pl. 19c.
H., p. 661.
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♂ vi.28.40 (H.H.).

113. **Pieris protodice** Boisduval & Le Conte.

G. & S., **2**: 130, 724.
R., p. 59.
H., p. 661.
Sabinas Hidalgo, Nuevo Leon, 960 ft., 1 ♀ vi.15.39 (H.H.).
Hda. Vista Hermosa, nr. Villa Santiago, Nuevo Leon, 1600 ft., 1 ♂ 3 ♀♀ vi.16.40 (H.H.).
Galeana, Nuevo Leon, 6500 ft., 1 ♀ viii.1.39 (H.H.).
Monterrey, Nuevo Leon, 1600 ft., 1 ♀ iv.27.41 (R.P.).
nr. Villagran, Tamaulipas, 1160 ft., 1 ♂ 1 ♀ iv.28.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ vi.28.40 (H.H.).

114. **Pieris rapæ** Linnæus.
R., p. 58, pl. 19b.
H., p. 661.
Galeana, Nuevo Leon, 6500 ft., 2 ♂♂ viii.4.39 (H.H.).

This species seems to have reached Mexico since the publication of the *Biològia* (since 1900?).

116. **Leptophobia aripa** Boisduval.
G. & S., **2**: 136, 726 (as *elodia*).
R., p. 60, pl. 19d.
H., p. 661.
nr. Villagran, Tamaulipas, 1160 ft., 1 ♀ iv.28.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 2 ♂♂ vi.28.39 (H.H.).
Fortin, Vera Cruz, 1600 ft., 1 ♂ v.3.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ v.12.41 (R.P.).
Orizaba, Vera Cruz, 200 ft., 1 ♂ v.6.41 (R.P.).

117. **Itaballia demophile calydonia** Boisduval.
G. & S., **2**: 131.
R., p. 63.
H., p. 661.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ v.29.41 (R.P.).

The subapical cross bar on the upper sides of the forewings is totally lacking, on the underside it is reduced to little more than a broad line. This specimen extends the range northward from southern Vera Cruz (see H., p. 661).

119. **Pieriballia viardi viardi** Boisduval.
G. & S., **2**: 133, 725, pl. 62, f. 1–4.
R., p. 62.
H., p. 661.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ iv.31.41 (R.P.).
El Pujal, San Luis Potosi, 100 ft., 1 ♂ 1 ♀ vii.20–21.39 (H.H.).

121. **Ascia monuste cleomes** Boisduval.
G. & S., **2**: 132, 725 (as *monuste*).
R., p. 57.
H., p. 662.

Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1600 ft., 1 ♀ vi.17.40 (H.H.).

Galeana, Nuevo Leon, 6500 ft., 1 ♀ iv.29.41 (R.P.).

nr. Villagran, Tamaulipas, 1160 ft., 1 ♀ iv.28.41 (R.P.).

Arroyo del Meco, Tamaulipas, 1 ♂ iv.28.41 (R.P.).

C. Victoria, Tamaulipas, 2 ♀♀ vi.27.35 (H. A. Freeman); 2 ♂♂ vi.19.39 (H.H.).

60 mi. So. of Victoria, Tamaulipas, 3 ♂♂ vii.6.36 (H.D.T.).

Jacala, Hidalgo, 5400 ft., 1 ♂ 1 ♀ vii.1.39 (H.H.).

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♂♂ v.29.41 (R.P.).

Arroyo del Calabezas, San Luis Potosi, 250 ft., 1 ♂ 10.30.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ 2 ♀♀ vi.26.40, vii.19.39 (H.H.).

El Pujal, San Luis Potosi, 100 ft., 3 ♂♂ vii.17–19.39 (H.H.).

Tuxpango, Vera Cruz, 1500 ft., 1 ♂ v.9.41 (R.P.).

Hda. Potrero Viejo, Paraje Nuevo, Vera Cruz, 1500 ft., 1 ♀ v.5.41 (R.P.).

Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.).

Apatzingan, Michoacan, 1200 ft., 2 ♂♂ 1 ♀ viii.5.40 (H.H.).

The males are rather uniform throughout. The marginal dark spots on the hindwing are variable, being represented by either a few scales or a small triangular patch. This does not seem to be related to the origin of the specimens. One male from 60 miles South of Victoria is almost immaculate on both upper and lower surfaces. The females fall into two clearly defined groups. Those from Nuevo Leon, Tamaulipas and Michoacan have a pinkish iridescence on the upper surface and one (from Victoria) approaches *phileta* Fabricius. Those from San Luis Potosi, Hidalgo and Vera Cruz are a dull buff-yellow on the hindwings and the same with a slightly pinkish tone on the forewings.

123. **Melete isandra** Boisduval.

G. & S., **2**: 139, 726, pl. 61, ff. 13, 14.

R., p. 77, pl. 23b.

H., p. 662.

El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♂ 1 ♀ vii.19.39 (H.H.).

El Pujal, San Luis Potosi, 100 ft., 3 ♂♂ vii.17–20.39 (H.H.).

BIBLIOGRAPHY

(1). GODMAN & SALVIN, Biologia Centrali-Americana, Rhopalocera, 2: 113–188. 1889–1890.

(2). ROEBER, in Seitz' Macrolepidoptera of the World, vol. 5, pp. 53–111. 1909.

(3). HOFFMANN, Anales del Instituto de Biologia, 11: 639–739. 1940.

(4). KLOTS, Entomologica Americana, 9: 99–171. 1929.

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A GENERIC REVIEW OF THE SUBFAMILY PHYLLOBÆNINÆ (OLIM HYDNOCERINÆ) (COL.)

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It has become increasingly evident that the genera of this subfamily are in a very chaotic condition, and that they are neither clearly defined nor readily understood. This state of confused conditions has been produced by various causes, such as the inclusion within the group of extraneous elements, which should have been assigned elsewhere; the omission of certain genera; disregard of the rules of priority and nomenclature; the all too frequent totally inadequate diagnoses and the lack of an ample and accurate synonymy, all of which have been contributing factors tending to create the utmost disorder.

In the present paper the writer will endeavor to eliminate the alien elements, to tabulate the several genera which are components of this subfamily, to give where needful, or at all possible an amended diagnosis, to give an ample synonymy, to indicate the type of each genus and record their geographic range.

PHYLLOBÆNINÆ SUBFAMILY *nom. nov.*

Subfamily Characters

Cleridæ; maxillary palpi with terminal segment cylindrical, usually much shorter than that of the labial palpi, which are large, dilated and securiform. Head with the eyes included broader than the prothorax; antennæ short; eleven-segmented (with the exception of one or two genera), usually with a two-

to five-segmented clava (rarely feebly developed). Thorax with the sides more or less dilated at, or before the middle. Elytra usually elongate, completely covering the abdomen, or more or less abbreviated, elytral sculpture variable. Terminal segments of abdomen, especially in the male, with sexual modifications. Legs long, slender, tarsi five-segmented, basal segment very small, atrophied or wanting, when present covered by the second segment, or elongate and distinct, not at all hidden from view from above.

The following key to the genera, studied in connection with the generic diagnosis which follow, will, it is believed, render possible a ready recognition of the several genera.

KEY TO THE GENERA

1. Antennæ ten-segmented, clava uni-segmented .. *Lasiocallimerus* Corp.
   Antennæ eleven-segmented .... 2.
2. Antennal clava indistinct .... 18.
   Antennal clava distinct; basal segment of hind tarsi small, atrophied or absent, usually covered by the second segment .... 3.
3. Clava two-segmented .... 4.
   Clava three- to five-segmented .... 8.
4. Terminal segment of clava larger than the tenth *Parmius* Sharp.
   Terminal segment of clava subequal in size to tenth, sometimes connate, causing the antennæ to appear ten-segmented *Neohydnus* Gorh.
   Terminal segment of clava minute or very small 5.
5. Tarsal ungues with a broad basal tooth . *Phyllobænus* Dej.
   Tarsal ungues simple or at most only slightly thickened at base . 6.
6. Prothorax much longer than broad; third segment of antennæ about twice as long as broad, cylindrical . . *Isohydnocera* Chpn.
   Prothorax subequilateral .... 7.
7. Third segment of antennæ stout, only slightly longer than broad. *Emmepus* Motsch.
   Third segment of antennæ as broad or broader than long, trapezoidal. *Wolcottia* Chpn.
8. Clava three-segmented; basal segment of hind tarsi short .... 9.
   Clava three- to five-segmented; basal segment of hind tarsi long, not covered by the second segment .... 15.
9. Clava rather indistinct; prothorax one-half longer than broad. *Cephaloclerus* Kuw.
   Clava distinct .... 10.
10. Body apterous; eyes coarsely granulate .... *Paupris* Sharp.
    Body alate; eyes finely granulate .... 11.
11. Eyes flat or depressed .... *Abrosius* Fairm.
    Eyes strongly convex .... 12.

12. Eyes large, globular, entire . . . . . . *Isolemidia* Gorh.
    Eyes smaller . . . . 13.
13. Tarsi of hind legs nonlamellate . . . . . *Metaxina* Broun.
    Tarsi of hind legs with at least two segments lamellate . 14.
14. Clava lax, serrate . . . . . *Eurycranium* Blanch.
    Clava rather compact; eyes feebly emarginate *Lemidia* Spin.
15. Very small (3 mm.), *Phyllobænus*-like in form . *Theano* Cast.
    Much larger (5 mm. or more) . . . . 16.
16. Form broad and compact; elytra never with scales; clava five-segmented . . . sub. gen. *Brachycallimerus* Chpn.
    Form elongate or oblong; adorned with white or yellow scales 17.
17. Head, the eyes included, only slightly broader than the anterior part of the prothorax sub. gen. *Callimerus* Gorh.
    Head, the eyes included, much broader than the anterior part of the prothorax; body depressed . sub. gen. *Cucujocallimerus* Pic.
18. Elytra depressed, much broader than the prothorax at base, elongate. *Evenus* Cast.
    Elytra convex, elongate, only slightly broader than the prothorax at base . . *Allelidea* Waterh.

Genus PHYLLOBÆNUS Dejean

A hundred and twenty years ago Thomas Say (Jour. Acad. Phila., III, 1823, p. 192), described an insect to which he gave the name *Clerus humeralis*, a year later E. F. Germar (Ins. Spec. Nov., I, 1824, p. 80) described the same insect (which had evidently come into his possession bearing a label with the name given to the species by Say), as he adopted for his species the name of *Clerus humeralis*, thus creating a synonym of Say's species. Several years later Count Dejean (Cat. des Col. de la coll., edition 3, 1837, p. 127) included under *Phyllobænus* Dejean, *humeralis* Germ., which is the first and only valid species, contained in the list of ten names, nine of which are given with "Dej." as author, but as he did not describe any of these species they are to be considered as *nomina nuda*. Dejean's citation of *humeralis* Germ., according to the International Code (*vide* Article 21 and Opinion 1, B) constitutes an indication, and gives validity to the genus *Phyllobænus* Dejean, with *P.* (*Clerus*) *humeralis* Say as the genotype.

Edward Newman (1838: 379) erected the genus *Hydnocera* based on *serrata* Newm., which is a synonym of *pallipennis* Say (1825: 176). Newman two years later (1840: 362) described

three more species of this genus, at which time he states that "The Count Dejean, in his 'Catalogue des Coleopteres' has given to the genus the provisional name of *Phyllobænus:* this I learn by finding one of them so named by Dr. Harris." He also remarks "One of the species has been described by Germar, in his 'Insectorum Species,' under the name of *Clerus humeralis;* and the same insect has also been labeled as the *Tillus humeralis* of Say, but I have no reference whatever to any description by the American entomologist." Newman's statements show how deeply he was imbued with the antiquated and obsolete idea that a generic name unaccompanied by a characterization or diagnosis was of no significance. And upon this supposition some of these names have been freely and rashly employed as names to designate other genera. An instance of the kind just mentioned is that of *Phyllobænus* Spinola (Clérites II, 1844, p. 1), of which he makes the following statements: "My *Phyllobènes* are not those of M^r^. Dejean, the latter belong to the *G.*[enus] *Hydnocera* of M^r^. Newman, a genus of which that author has published the characters and of which he is the true founder, the name that he has assigned to it has incontestably the right of priority. That of *Phyllobænus* having become vacant, I like it better to take possession of it than rack one's brains in looking for a new name to apply to a species that M^r^. Dejean has placed in the *G.*[enus] *Notoxus* and which cannot remain there." The action of the present writer in assigning *Phyllobænus* to its proper nomenclatural status leaves *Phyllobænus* Spinola vacant, and necessitates a new name in its stead, the name *Phlogisto-sternus* φλογιστός, crematus στέρνον, sternum, is here proposed.

Genotype.—*Phyllobænus dislotatus.*

The writer's thanks are due his good friend Dr. Edward A. Chapin, Curator Division of Insects, United States National Museum, who has assisted the author in many ways; also it was he who first called the author's attention to the fact that *Hydnocera* Newman is a synonym of *Phyllobænus* Dejean.

Phyllobænus Dejean, Cat. des Col., 3rd Edition, 1837, p. 127.

Hydnocera Newman, The Ent. Mag., Lond., V, 1837 (1838), p. 379.—Newman, Mag. Nat. Hist., (2) IV, 1840, p. 362.—Spinola, Rev. Zool., 1841, p. 75.—Klug, Clerii, 1842, p. 311.—Spinola, Mon.

Clérites, II, 1844, p. 39.—Leconte, Ann. Lyc. Nat. Hist. New York, V, 1849, p. 26.—Lacordaire, Gen. Col., IV, 1857, p. 471.—Chenu, Encycl. d'Hist. Nat. Col., II, 1860, p. 268.—Leconte, Classif. Col. N. Amer., I, 1861, p. 196.—Gorham, Trans. Ent. Soc. Lond., 1877, pt. 3, p. 260.—Gorham, Biol. Centr.-Amer., III, pt. 2, 1883, p. 168.—Leconte and Horn, Classif. Col. N. Amer., ed. II, 1883, p. 218.—Wickham, Can. Ent., XXVII, 1895, pp. 245 and 251.—Schenkling, Gen. Ins. (Wytsman) Cler., 1903, p. 92.—Schenkling, Col. Cat. (Junk) Cler., pt. 23, 1910, p. 102.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Wolcott, Bull. Ind. Dept. Geol. Nat. Res., I, 1910, p. 855.—Chapin, Bull. Brookl. Ent. Soc., XII, 1917, p. 83.—Chapin, Proc. Biol. Soc. Wash., XXXV, 1922, p. 55.—Bradley, Man. Gen. Beetles Amer. N. of Mex., 1930, p. 105.—Chagnon, Le Nat. Canad., LXII, 1935, pp. 174 and 175.

Theano Chevrolat, Ann. Soc. Ent. France, I (2), 1843, p. 33.

Diagnosis of *Phyllobænus* Dejean

Head, with the eyes included, broader than the prothorax, mandibles feebly curved with a strong internal tooth before the apex. Head very short, front large, vertical, eyes rather large, prominent, oval, transverse, entire or the front margin with a feeble vestige of emargination. Antennæ very short, eleven-segmented, first segment thick, obconical, second very short, segments three to nine nearly cylindrical, the ninth segment as broad as long, tenth segment large, swollen, ovate, terminated by the scarcely discernible, minute eleventh segment. Maxillary palpi with terminal segment short, nearly cylindrical or attenuate, apex truncate, terminal segment of labial palpi large, transversely securiform. Prothorax usually longer than broad, sides more or less dilated before the middle. Elytra much broader than the prothorax at base, usually moderately elongate parallel or narrowed near the middle, often abbreviated at apex, sculpture variable. Legs long, posterior femora reaching slightly beyond the apex of the elytra, tarsi five-segmented, basal segment short, the three succeeding lamellate, the posterior tarsi with the lamella of basal segment long and compressed, lamellæ of second and third segments depressed, bifid. Ungues with a broad basal tooth.

Newman in his diagnosis of the genus *Hydnocera* states that the antennæ are 10-articulate, but it is evident that he failed to observe the very small and closely united true apical segment. This error was corrected by Lacordaire (1857: 471).

Genotype.—*Phyllobænus* (*Clerus*) *humeralis* Say. Monobasic.

Geographical range, 118 species of North, Central and South America.

Genus LEMIDIA Spinola

Lemidia Spinola, Rev. Zool., 1841, p. 75.—Klug, Clerii., 1842, p. 311.—Spinola, Clérites, II, 1844, p. 32.—Lacordaire, Gen. Col., IV, 1857, p. 470.—Chenu, Encycl. d'Hist. Nat. Col., II, 1860, p. 267.—Gorham, Trans. Soc. Ent. Lond., 1877, p. 249.—Schenkling, Deutsch. Ent. Zeit., 1898, p. 169.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 90.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 108.—Lea, Ann. Soc. Ent. Belg., LI, 1907, pp. 331 et 362.

Eumede Pascoe, Ann. Mag. Nat. Hist., (4) XVII, 1876, p. 50.—Broun, Man. New Zealand Col., I, 1880, p. 334.

Hydnocera Newman, The Entom., 1841, p. 36.—Newman, *idem*, 1842, p. 365.—White, Cat. Cleridæ Brit. Mus., IV, 1849, pp. 61 et 62.

Clerus Newman, Zoologist, 1843, p. 119 (sp. *hilaris*).

Hoploclerus White, *l.c.* p. 40.—Westwood, Proc. Zool. Soc. Lond., XX, 1852, p. 52.

Hydnocerus Westwood, *loc cit.*, 1852, p. 47.

Lemidius Westwood, *idem*, 1852, p. 47.

Laiomorphus Pic, Mél. Exot.-ent., L, 1937, p. 20.

Diagnosis of *Lemidia*, revised

Body small, rather elongate, parallel or posteriorly wider. Head short, with the eyes broader than the prothorax, front broad between the eyes, which are large, prominent, feebly, shallowly emarginate in front, finely granulated. Maxillary palpi with the terminal segment cylindrical, somewhat oval, acute at apex; that of the labial palpi much larger, depressed, securiform. Labrum prominent, emarginate. Antennæ very short, reaching the hind margin of the head, eleven-segmented, segment 1 thick and long, subcylindrical, not rising to the height of the front, segment 2 very short, swollen at middle and subglobular, segments

3 to 8 short, diminishing in length, without becoming sensibly narrower, segments 9 to 11 thick and depressed, equally dilated, forming a quite distinct clava of these three segments, the first two are equal, subtransverse, the last longest and oval. Prothorax longer than broad, narrower than the head, much narrower at base, anteriorly with at most a feeble transverse impressed line. Elytra oblong, surface depressed, entirely covering the abdomen, irregularly punctured, suture usually closed, spices conjointly rounded, rarely separately mucronate. Legs long and slender, the femora extending to or beyond apex of the elytra, tarsi five-segmented (four segments only visible from above), the first segment very small or rudimentary but usually perfectly visible from below, the first three lamellate, the second, third and fourth segments diminishing in length. Ungues small, simple or at most with an indistinct tooth at base.

Genotype.—*Lemidia* (*Hydnocera*) *nitens* Newman (Spinola). Monobasic.

Geographical range, sixty-two species of this genus are found in Australia, one in New Zealand, two in Tonkin, and seven in Tasmania.

Genus ISOHYDNOCERA Chapin

Isohydnocera Chapin, Bull. Brookl. Ent. Soc., XII, 1917, p. 83.—Bradley, Man. Gen. Beetles Amer. N. of Mex., 1930, p. 105.

Diagnosis of *Isohydnocera*

"Body very elongate; front vertical; eyes prominent, finely granulate, entire or minutely emarginate near antennal insertion; terminal segment of maxillary palpi cylindro-conical, that of labial palpi large, triangular; mandibles with a tooth near apex on the inside. Antennæ 11-segmented, first segment thick, moderately long and somewhat arcuate, second short, globose, third to ninth cylindrical, longer than broad, tenth very large, forming with the eleventh a compact club which is much thicker than the ninth segment. Prothorax distinctly longer than broad, nearly cylindrical, lateral dilation weak. Elytra broader than the thorax, shorter than the abdomen, attenuate or parallel and truncate, lateral margins and usually tips strongly serrate. Legs long and thin, tarsi with five segments, the first covered by the

second from above, segments two, three and four bearing lamellae beneath, ungues long and thin, simple" (Chapin).

"To this genus are to be assigned the following species: *I. curtipennis* Newman (*longicollis* Ziegl.), *tabida* Lec., *schusteri* Lec., *ornata* Wolc., *gerhardi* Wolc., *pusilla* Schaeff., *aegra* Newm., *brunnea* sp. nov. and *albocincta* Horn" (Chapin).

Genotype.—*Isohydnocera* (*Hydnocera*) *curtipennis* Newman, designated by Chapin.

Geographical range, North, Central and South America.

Genus WOLCOTTIA Chapin

Wolcottia Chapin, Bull. Brookl. Ent. Soc., XII, 1917, p. 84.—Bradley, Man. Gen. Beetles Amer. N. of Mex., 1930, p. 105.

Diagnosis of *Wolcottia*

"Body elongate, slightly attenuate posteriorly. Head short, front flat, lateral margins slightly concave to accommodate eyes, which are not prominent, finely granulate and minutely emarginate as in *Isohydnocera*. Labrum broad, entire. Mandibles falciform, with a small internal tooth near apex. Terminal segment of maxillary palpi conical, as long, or slightly longer than the preceding, that of the labial palpi very large, triangular. Antennæ short and stout, 11-segmented; first segment slightly longer than broad, second nearly spherical, third to eighth as long as broad, trapezoidal, becoming progressively broader, ninth broader than long, nearly as wide as tenth, tenth and eleventh forming an oval mass nearly as long as the three preceding segments. Thorax slightly broader than long, sides feebly dilated, slightly narrower than the head with eyes. Elytra at humeri broader than the head across eyes, attenuate posteriorly, tips rounded separately and with irregular margins. Legs long and thin, hind femora reaching beyond the tips of the elytra, tarsi of five segments, the first covered by the second from above, second, third and fourth bearing lamellæ beneath. Ungues long and thin, simple or but slightly thickened" (Chapin).

Genotype.—*W.* (*Hydnocera*) *pedalis* Leconte, designated by Chapin.

Geographical range, North America.

Dr. Chapin states that "The three species assigned to this genus, *W. pedalis* Lec., *sobrina* Fall, and *parviceps* Schaeffer, have antennæ which seem to be midway between the three-segmented club type of *Lemidia* Spinola and the two-segmented club type of *Hydnocera* Newman."

Genus PARMIUS Sharp

Parmius Sharp, Ent. Mo. Mag., XIII, 1877, p. 272.—Broun, Man. New Zealand Col., I, 1880, p. 331.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 96.—Schenkling, Col. Cat., (Junk) Cleridae, pars 23, 1910, p. 112.

Diagnosis of *Parmius,* revised

Elongate, alate, slender. Head with the eyes as broad as the elytra, broader than the thorax. Terminal segment of the maxillary palpi small, that of the labial palpi very large and broad. Eyes very prominent, finely granulated, entire or with a more or less definite emargination, antennæ short and rather slender, 11-segmented, the two or three terminal segments forming a short, broad clava, the tenth being strongly transverse and the eleventh rather stouter than the tenth and hardly as long as broad. Thorax subcylindrical but a little dilated at the middle, about as long as broad, but narrower than the elytra, constricted in front and behind, very narrow and parallel, the humeri distinct and rectangular. Legs long, tarsi moderately long and broad, very distinctly five-segmented, the second segment inserted very near the tibia. Hind coxæ rather widely distant.

"The two species (*debilis* Shp., and *longipes* Shp.,) differ from *Paupris aptera* by their finely granulated eyes, by the presence of wings and the more normal form of the elytra" (Sharp).

Genotype.—*Parmius longipes* Sharp, by present designation.

Geographical range, four described species known, all from New Zealand.

Genus NEOHYDNUS Gorham

Neohydnus Gorham, Ann. Mus. Genova, (2) XII, 1892, p. 742.—Schenkling, Gen. Ins., (Wytsman) Cler., fasc. 13, 1903, p. 94.—Schenkling, Col. Cat., (Junk) Cleridae, pars 23, 1910, p. 107.—Chapin, Phil. Jour. Sci., XXV, No. 2, 1924, p. 180.

Emmepus Motchoulsky, Bull. Imp. Nat. Moscou, XXXIV, 1861, p. 127 (sp. *flavipes*).

Diagnosis of *Neohydnus*, revised

Head vertical. Labrum entire; mandibles stout, falcate, with a short internal tooth toward apex. Eyes large, finely granulated, pubescent, entire or minutely emarginate at base of antennæ; the head plane between the eyes (very much as in *Callimerus*). Terminal segment of maxillary palpi cylindro-acuminate, that of labial palpi dilated, elongate-triangular. Antennæ short 11-segmented (often apparently ten-segmented, the tenth and eleventh segments being anchylosed), first segment short and thick, slightly bent, second nearly spherical, third to ninth trapezoidal, becoming successively shorter to eighth or ninth, ninth sometimes longer than the eighth, tenth and eleventh together oval and flattened. Thorax with length and breadth subequal, not widened in front (as in *Phyllobænus*), with a constricted line near the front, sides slightly dilated below this construction, lateral foveæ deep, oblique above dilations, usually two or three in number, no basal constriction but margined at base, anterior coxal cavities widely open behind. Elytra usually as long as body, confusedly punctate, no trace of striæ, suture slightly dehiscent toward apices, lateral margin and tips usually strongly serrate. Abdomen with six visible ventral segments. Sexual modifications of males usually conspicuous. Legs slender, femora somewhat swollen; tarsi short, of five segments, first segment short and ventral to second, ungues with a broad basal process.

Genotype.—*Neohydnus despectus* Gorham.

Geographical range, Indo-Malaysia.

Genus METAXINA Broun

Metaxina Broun, Ann. Mag. Nat. Hist., (8) III, 1909, p. 407.

Diagnosis of *Metaxina*, revised

Head (eyes included) nearly as large as the thorax, forehead limited between the antennæ by a slightly raised suture. Palpi stout, long, the terminal segment of maxillary palpi quite oblique

at apices; that of the labial palpi subtriangular or securiform, truncate at apices. Eyes prominent, distinctly granulated, apparently rotundate, in reality transversely broadly oviform, entire. Antennæ eleven-segmented, inserted not in cavities, but on slight prominences, or articulations in front of the eyes; basal segment stout, pyriform, third segment slightly longer than second or fourth; segments four to eight nearly equal in breadth, each longer than broad, and narrowed at the base; segments nine and ten distinctly broader than the preceding, but little longer; eleventh rather larger and oviform; these organs therefore more nearly resemble those of *Paupris* and *Parmius* than of *Phymatophæa*. Prothorax somewhat cordiform, transverse, apex truncate, base rounded, the lateral margins fine and curved toward the base, but without forming posterior angles; scutellum elongate. Prosternum truncate in front. Coxæ with trochanters; the anterior prominent, separated only by the prosternal process; intermediate rather less prominent, almost contiguous; the posterior small, only moderately separated. Metasternum moderately elongate, its sides distinctly punctured. Elytra parallel-sided, broader than the thorax, with obtusely prominent humeri, the punctuation moderately coarse, not close and subseriate, surface subdepressed, apices not quite smooth, elongate. Tarsi five-segmented, basal segment abbreviated above, its lobes prolonged below; segments two to four of nearly equal length, their lobes also prolonged but without perceptible lamellæ underneath; fifth simple, nearly as long as the preceding four together; basal segments of the anterior tarsi furnished with long slender, brush-like setæ below. Abdomen composed of six segments, the basal segment rather larger than the others, segments two to five about equal; sixth short, deeply emarginate, with a supplementary conical segment protruding therefrom.

Genotype.—*Metaxina ornata* Broun, designated by Broun.

Geographical range, 1 species of New Zealand.

Broun remarks that "the type of this genus is quite unlike any Australian or New Zealand species known to me, and certainly an aberrant form, owing to the absence of tarsal lamellæ, the unnotched eyes, &c." This genus and its genotype has not been mentioned in the literature since the genus was created by

Broun. This is truly an anomalous genus, but this being an insular insect, and obviously a highly adaptive form, the singularity of its aspect need cause no great doubt as to the propriety of including this genus in the present subfamily.

Genus ABROSIUS Fairmaire

Abrosius Fairmaire, Bull. Mus. Hist. Nat., Paris, VIII, 1902, p. 315.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 96.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 112.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.

Diagnosis of *Abrosius* translated from the original

"This new genus of Cleridæ approaches the Hydnocerides by the tarsi having the first segment indistinct, the eyes entire and the antennæ inserted near their lower border; but the eyes are rather depressed, the legs of ordinary length and the facies is very different from that of *Evenus,* recalling greatly that of *Aulicus.* The antennæ are slender, of eleven articles, the three terminal segments forming a small, rather narrow, lax mass; the front is rather large, but the eyes moderately convex. Prothorax scarcely longer than broad, base moderately narrow, sides rounded, scarcely sinuate at base. Elytra oblong, humeri rather angulate, surface with basal portion rather strongly seriate-punctate, posteriorly minutely and confusedly punctate. Legs slender, rather short, tarsi seen from above four-segmented, the first segment indistinct, the intermediate segments provided with rather long lamellæ."

Genotype.—*Abrosius cyaneorufus* Fairm., by sole inclusion.

Geographical range, 1 species of Madagascar.

The genus *Abrosius* is unfortunately unknown in nature to the writer, otherwise additional characters would be given to enable recognition of this very poorly characterized genus, the diagnosis of which fails to mention the chief characters usually employed for this purpose, such as the structure of palpi, and gives only a very ambiguous and contradictory account of the eyes and an inefficient description of the legs and the tarsi.

Genus CEPHALOCLERUS Kuwert

Cephaloclerus Kuwert, Ann. Soc. Ent. Belg., XXXVII, 1893, p. 486.—Kraatz, Deutsch. Ent. Zeit., 1899, p. 105.—Schenkling,

Bull. Mus. d'Hist. Paris, VIII, 1902, p. 330 (in species).—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 90.—Hintz, Deutsche. Ent. Zeitschr., 1905, p. 312.—Schenkling, Deutsch. Ent. Zeit., 1906, heft 2, p. 300.—Gahan, Ann. Mag. Nat. Hist., Lond., (8) V, 1910, p. 65.—Schenkling, Col. Cat., (Junk) Cleridae, 1910, p. 111.

Hydnocera Boheman, Ins. Caffr., I, fasc. 2, 1851, p. 511.

Diagnosis of *Cephaloclerus*, revised

Head large, rather strongly rounded, with the eyes much broader than the thorax, clypeus strongly emarginate, labrum emarginate; terminal segment of maxillary palpi short, slender, cylindrical, acute at apex; that of labial palpi larger, bell-shaped. Antennæ very short, scarcely longer than the thorax, eleven-segmented, slender, segments four to ten very short, serrate, clava elongate, but little distinct, three-segmented, terminal segment rounded, its apex obtuse, within subacuminate, eyes large, ovate, entire, moderately convex, prominent. Thorax nearly one-half longer than broad, angles strongly rounded, margins acute, posteriorly bisinuate, apex truncate, narrower than the head, sides before the middle nearly straight then behind the middle abruptly narrowed, posteriorly narrower, basal margin truncate, thinly reflexed, near apex and near base a transverse impressed line, surface slightly convex, sides at apex and base narrowly constricted. Elytra oblong-quadrate, narrower than the head, nearly three times as long as the thorax and twice as broad as the thorax at base, base slightly broadened, obliquely truncate, humeri strongly rounded, not elevated, sides thinly margined, straight (sinuate in *C. basalis*), apex conjointly rounded, coarsely and deeply punctate. Legs slender, posterior tarsi viewed from above evidently four-segmented, segments one, two and three dilated, penultimate segments lamellate, ungues simple.

Genotype.—*Cephaloclerus corynetoides* Kuwert. Monobasic.

Geographical range, 23 species, all of Africa.

Genus EURYCRANIUM Blanchard

Eurycranium Blanchard, Hist. Ins., II, 1845, p. 87.—Chenu, Encycl. d'Hist. Nat. Col., II, 1860, p. 245.

Eurycranus Blanchard, Hist. Ins., II, 1845, p. 84.—Gemm. et Harold, Cat. Col., VI, 1869, p. 1745 (pars).—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 64 and 65.

Eurymetopum Blanchard, Voy. d'Orb., 1844, p. 92.[1]—White, Nomenc. Col. Ins. Brit. Mus. Cler., IV, 1849, p. 42.—Chevrolat, Cat. des Cler., Rev. Mag. Zool., 1874, p. 275.

Epiclines Spinola, Gay Hist. Chile, Zool., IV, 1849, p. 386 (pars).—Lacordaire, Gen. Col., IV, 1857, p. 463 (pars).—Gemminger et Harold, Cat. Col., VI, 1869, p. 1745 (pars).—Gorham, Cist. Ent., II, 1876, p. 91 ("*nil ad rem*").—Lohde, Ent. Zeit. Stett., IX, 1900, p. 71.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 71 (pars).—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 99 (pars).

Clerus Spinola, Mon. Clér., II, 1844, p. 158 (in species).

Thanasimus Spinola, Gay Hist. Chile, Zool., IV, 1849, p. 392 (pars).—Fairmaire et Germain, Col. Chilensia, Paris, II, 1861, p. 3.—Philippi, Stett. Ent. Zeit., XXV, 1864, p. 266 (pars).—Philippi, Ann. Univ. Chile, Santiago, XXVI, 1865, p. 656 (in species).

Dereutes Chevrolat, Mém. des Clerites, 1876, p. 29 (pars) (a group name only!).

Thereutes Harold, Col. Hefte, XVI, 1879, p. 248 (pars) (*inutilis emendat.*).

Diagnosis of *Eurycranium*, revised

Head short, very wide across the eyes, which are very prominent and nearly entire. The maxillary palpi are short, the terminal segment elongate, conico-cylindrical, that of the labial

1 *Eurymetopum* Blanchard is preoccupied by *Eurymetopon* Eschscholtz, Atlas, Zoologique du voyage du capitaine Kotzebue, fascicule 2, p. 8, pl. 18, figs. 1 and 2, to designate a genus of the family Tenebrionidæ. Later Schönherr (Genera et Species Curculionidum, Paris, VI, 1, 1840, p. 112) employed the name *Eurymetopus* to designate a genus of Tetramerous coleoptera, of the Brachypterous Curculionides. This author has described but one species (*E. fallax*) of the great number now known from South America. Chevrolat says (Mém. Cler., p. 30), "The three names represent the same root. That [of *Dereutes*] which I employ indicates the mode of life of the greater part of the true clerides. Not only do they live on insects in the larval state, but arriving at the perfect state they run on the bark of trees pouncing upon those that they meet devouring them with avidity."

palpi securiform, very large, the mandibles are rather small with a feeble tooth on internal side. Antennæ slender, long, eleven-segmented, nearly as long as head and thorax united, the funicle very long with the three last segments of antennæ forming a small ovate, serrate clava. Prothorax long, cylindrical and constituting nearly a third of the total length of the insect, sides of thorax more or less broadly dilated at middle, apical and basal constrictions and transverse impressions usually quite feeble, basal margin thinly reflexed. Elytra rather long, entirely covering the abdomen, flexible, suture closed, apex conjointly rounded, surface very uneven, puncturing imperceptible. Legs moderately long, slender, tarsi five-segmented, first segment very short and small, but still visible from above, the second longer than the first but still less stout, third slightly shorter than the second, fourth dilated.

Genotype.—*E. maculatum* Blanchard, by present designation.

Geographical range, South and Central America.

Genus PAUPRIS Sharp

Paupris Sharp, Ent. Monthly Mag., XIII, 1877, p. 271.—Gorham, Trans. Ent. Soc. Lond., 1877, p. 263.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 95.—Broun, Man. New Zealand Col., I, 1880, p. 331.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 95.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 112.

Diagnosis of *Paupris*, revised

Elongate, apterous. Head (the eyes included) rather broader than the thorax at its broadest part. Eyes rather small, moderately prominent, coarsely granulated, with a very small triangular excision. Maxillary palpi with terminal segment small and cylindrical, not at all dilated, while that of the labial palpi is very large, transversely broad, and dilated. Antennæ short and stout, inserted well before the eyes, eleven-segmented, segment two shorter than the third, segments of the funicle three to eight all subequal in length, segments nine to eleven each broader than long, about twice as broad as the preceding segments, the terminal segment as broad as long, its apex subacuminate, these segments

forming a rather lax clava. Prothorax elongate and narrow, longer than broad, sides at middle somewhat dilated, but scarcely tuberculate. Elytra small and narrow, much abbreviated, usually nearly three dorsal segments shorter than the abdomen, base narrow, humeri absent, suture closed, elongate-obovate, very sparsely covered with short erect coarse hairs, apex conjointly rounded. Legs long and rather stout, tarsi moderately broad, five-segmented, first segment very small and short, nearly covered by the elongate second segment, segments three and four each shorter than the second, and strongly lamellate, ungues small, simple.

Genotype.—*Paupris aptera* Sharp. Monobasic.

Geographical range, one species of New Zealand.

Genus ISOLEMIDIA Gorham

Isolemidia Gorham, Trans. Ent. Soc. Lond., 1877, pp. 249, 257.—Gorham, Biol. Centr.-Amer., III, pt. 2, 1883, p. 177.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 92.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 107.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Wolcott, Publ. Field Mus. Nat. Hist., Zool., VII, 1910, p. 376 (in species).—Chapin, Proc. Ent. Soc. Wash., XXII, 1920, pp. 51 and 52 (in species).

Diagnosis of *Isolemidia*, revised

Head with the eyes broader than the thorax, eyes very large, globular, entire or at most minutely emarginate, maxillary palpi subfiliform, terminal segment truncate at apex; that of the labial palpi securiform. Thorax subcylindrical, but often short and sometimes quadrate or broader than long, the sides broadly rounded or tuberculate at middle, strongly constricted near apex and base, the basal and apical transverse impressed lines very distinct. Antennæ very short, usually little longer than the head, as in *Lemidia*, eleven-segmented, those segments succeeding the basal segment a little longer than wide, the three last transverse, forming a small, short, rather connate, oblong, clava. Elytra elongate, usually much broader than the thorax, and broadest behind the middle, the apex conjointly rounded, usually covering the abdomen, roundly truncate (*pulchella* Gorh.), the

humeri distinct, sometimes with a very small callus (*I. cariniceps* Wolc., the elytra are much abbreviated, the suture widely dehiscent, the apices separately obtusely rounded with a few well developed teeth). Legs long and slender, posterior femora moderately long, tarsi five-segmented, the basal segment as in *Lemidia*, atrophied, second segment covering the first, ungues simple.

Genotype.—*I. pulchella* Gorham, designated by Gorham.

Geographical range, thirteen species of South and Central America.

Genus EMMEPUS Motschoulsky

Emmepus Motschoulsky, Bull. Moscou., XVIII, 1845, p. 41 (sub Staphylin.).—Lacordaire, Gen. Col., IV, 1857, p. 494.—Chenu, Encycl. d'Hist. Nat. Col., II, 1860, pp. 82 and 266 (sub Staphylin.).—Gorham, Trans. Ent. Soc. Lond., 1877, p. 263.—Reitter, Verh. Nat. Ver. Brünn., XXXII, 1893 (1894), p. 39.—Reitter, Best. Tab., 1894, p. 6.—Reitter, Wien. Ent. Zeit., XV, 1896, p. 283.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 96.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 112.

Brachyclerus Fairmaire, Compt. rend. Soc. Ent. Belg., XXVII, 1883, p. 157.—Bedel, Ann. Soc. Ent. Fr., (6) VII, 1887, p. 197.

Diagnosis of *Emmepus*, revised

Body slender, small. Head transversely quadrate, front broad, mandibles internally with a distinct tooth near apex. Maxillary palpi with the terminal segment small, nearly cylindrical, at apex much smaller; that of labial palpi large, securiform. Eyes large, prominent, finely granulated, ? entire. Antennæ very short, eleven-segmented, the two first segments large and thick, the succeeding segments much shorter and more slender, the two terminal segments forming a ball-like clava, first segment of clava (the tenth of the antennæ) much swollen, partly covering the very small apical segment. Prothorax as long as broad, the sides at middle broadly subangulately dilated. Elytra twice as long as broad, much larger than the thorax, much shorter than the abdomen, suture strongly dehiscent, scarcely covering the abdomen behind the middle. The wings long, extending well beyond the apex of the abdomen which it covers. Legs long and

slender, tarsi rather long and slender, distinctly five-segmented, first segment longer than the second, segments three and four each successively shorter than the preceding segments, segments one to four with lamellæ beneath, segment five elongate-clavate, much longer than the two preceding segments united, ungues simple.

Genotype.—*Emmepus arundinis* Motsch. Monobasic.

Geographical range, three species known from Caucasus, Caspian Sea, South Algeria, Turkestan and Ceylon.

Genus THEANO Castelnau

Theano Castelnau, Silberm. Rev., IV, 1836, p. 51.—Lacordaire, Gen. Col., IV, 1857, p. 493.—Chenu, Encycl. d'Hist. Nat. Col., II, 1860, p. 268.—Gorham, Trans. Ent. Soc. Lond., 1877, p. 363.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 97.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 113.

Diagnosis of *Theano*, revised

Body small, rather long. Head with the eyes broader than the thorax. Labrum entire, its front arcuate, mandibles with an internal tooth near apex. Terminal segment of labial palpi large, securiform, acuminate at apex. Eyes moderately large, prominent, entire. Antennæ short, slender, eleven-segmented, the first two segments equal, rather large, the third segment slender, the succeeding five segments rather slender, trianguler, the last three segments forming a swollen, ovate or somewhat globular clava. Thorax much narrower than the head, rounded at the sides. Elytra somewhat elongate, surface very coarsely punctate. Legs long and slender, posterior femora extending slightly beyond the apex of the abdomen, tarsi with the basal segment conical, the succeeding three segments short, dilated and bifid, provided with prolonged lamellæ beneath.

Genotype.—*Theano pusilla* Cast. Monobasic.

Geographical range, one species from South America (Colombia).

Subgenus CALLIMERUS Gorham

Callimerus Gorham, Cist. Ent., II, 1876 (1875–1882), p. 65.—Schenkling, Gen. Ins., (Wytsman) Cler., fasc. 13, 1903, p. 24.—

Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 26.—Chapin, Philipp. Jour. Sci., XXV, No. 2, 1924, pp. 180 and 191.—Pic, Exot.-Ent., fasc. 54, 1929, p. 17 (pars).

Xylobius White, Nomenc. Col. Brit. Mus., Cler., IV, 1849, p. 50 (in species).—Westwood, Proc. Zool. Soc. Lond., XX, 1852, p. 40 (in species).

Lemidia Thomson, Mus. Scient., II, 1860, p. 61 (in species).—Pascoe, Jour. Ent., I, 1860, p. 48.—Chevrolat, Rev. Mag. Zool., 1874, p. 321.—Kuwert, Ann. Soc. Ent. Belg., XXXVII, 1893, p. 484.

Caloclerus Kuwert, Ann. Soc. Ent. Belg., XXXVII, 1893, p. 480.—Schenkling, Ann. Soc. Ent. Belg., VL, 1901, p. 105.

Diagnosis of *Callimerus,* revised

Form elongate, or oblong, head with eyes slightly broader than apex of thorax, eyes prominent, finely granulate, very slightly emarginate at base of antennæ. Labrum entire; mandibles stout, falcate, with internal tooth near apex; terminal segment of maxillary palpi twice as long as preceding segment, subulate; that of the labial palpi elongate-triangular. Antennæ rather short, slender, distinctly eleven-segmented, first segment stout, bent, at least twice the length of the second, which is from nearly as long as broad to equilateral and globular, segments three to eight much longer than broad, each segment shorter than the preceding, ninth to eleventh forming a lax, oval clava, the eleventh oval at apex. Thorax longer than broad, somewhat constricted before and behind, moderately to strongly dilated at or before the middle, anterior coxal cavities very widely open behind. Elytra entirely covering the abdomen, long, narrow, sides parallel or gradually becoming narrower posteriorly, adorned with white or yellow scales, these scales often forming a definite pattern, apex sometimes abbreviated and truncate or rarely each mucronate, surface variously punctate. Abdomen with six visible ventral segments; in the male the terminal segments are often profoundly modified; in the female the modification, if any, occurs on the penultimate segment. Legs rather long, posterior tibiæ with or without a notch with comb of hairs near its apex; tarsi moderately long,

five-segmented, the basal segment the longest. Ungues nearly simple or with a broad plate-like tooth.

Subgenotype.—*Clerus* (*Xylobius*) *dulcis* Westw., designated by Gorham.

Geographical range, 102 species known from Indo-Malaysia.

Subgenus CUCUJOCALLIMERUS Pic

Cucujocallimerus s. g. Pic, Mél. Exot.-ent., fasc. LIV, 1929, pp. 17–18.

Callimerus auct. (pars).

Diagnosis of *Cucujocallimerus*, slightly revised

Prothorax less than, or little longer than broad, or sometimes very elongate, posterior margin less narrow, often rather broad, or sometimes indistinct, femora more or less slender or a little stouter, sometimes the posterior stouter than the others; the tarsi the most often slender and long. Form of the body oblongo-elongate or narrow. Antennæ less short. Head with the eyes much broader than the front part of the prothorax, this very impressive. Body wholly, as a matter of fact, depressed above.

"The sub-genus *Cucujocallimerus mihi* has the legs principally the posterior femora much longer than the others, whereas the greater portion of the species of the s. genus *Callimerus* has them little or moderately longer than the others" (Pic).

Subgenotype.—*Cucujocallimerus* (*Callimerus*) *coomani* Pic., designated by Pic.

Geographical range, 1 species of Tonkin.

Subgenus BRACHYCALLIMERUS Chapin

Brachycallimerus Chapin, Philipp. Jour. Sci., XXV, No. 2, 1924, pp. 180 et 190.—Corporaal, Rev. Française d'Ent., IV, 1937, p. 60.

Callimerus auct. (pars), *loc. cit.*, p. 190.

Crassocallimerus Pic, Mél. Exot.-ent., LIV, 1929, pp. 17 et 18.

Diagnosis of *Brachycallimerus*, only slightly revised

Head broad, eyes very prominent, very slightly emarginate near antennal socket; labrum entire, mandibles broad and flat,

falcate, with a sharp tooth internally near apex; antennæ short and compact, eleven-segmented, first segment short and stout, second nearly spherical, third to sixth longer than broad, seventh to eleventh broader than long, each broader than the preceding, together forming a compact obtriangular five-segmented clava. Thorax broader than long, polished, with a few distinct punctures. Elytra broader at base than the thorax, punctures numerous, not seriate. Entire dorsal surface of insect devoid of scales. Abdomen with six visible ventral segments, secondary sexual modifications conspicuous. Legs moderate in length, posterior tibiæ with subapical notch, tarsi rather long and slender, five-segmented, first segment longer than the second, distinct and not covered by the second, ungues broadly toothed at base.

Subgenotype.—*Callimerus latifrons* Gorh., designated by Chapin.

Geographical range, Indo-Malaysia.

Chapin states that "The insects which I include in this new genus have heretofore been classified with the species of *Callimerus* Gorh. They differ from those species in their broad and compact form, short and compact antennæ, and the total absence of scales from the upper surface. In addition to the genotype, I would include the following species: *latesignatus* Gorh., *rusticus* Gorh., *pectoralis* Schklg., and probably *trifasciatus* Schklg." Corporaal (1937: 60) includes the last named species without question and adds *pallidus* Gorh., and *doesburgi* Corp., n. sp., as members of this genus.

Genus EVENUS Castelnau

Evenus Castelnau, Silb. Rev., IV, 1836, p. 41.—Spinola, Rev. Zool., 1841, p. 75.—Klug, Abhandl. Berl. Akad. 1842, p. 315.—Spinola, Mon. Clérites, II, 1844, p. 28.—Lacordaire, Gen. Col., 1857, p. 469.—Chenu, Encycl. d'Hist. Nat. Col., II, 1860, p. 266.—Gorham, Trans. Ent. Soc. Lond., 1877, p. 249.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 89.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Schenkling, Deutsche Ent. Zeitschr., 1906, p. 300.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 111.

Diagnosis of *Evenus*, revised

Body very narrow, filiform. Head large, constricted behind, front concave. Maxillary palpi small, terminal segment cylin-

drical, rounded at apex; labial palpi long, three times as long as the maxillary palpi, terminal segment elongate, securiform, slender at base. Eyes large, very prominent transversely oval, not visibly emarginate. Antennæ very short, inserted between the eyes and very near their extreme anterior margin, eleven-segmented, first segment rather stout, long, cylindrical, segments three to eight obconical, small but distinct, each progressively broader but without becoming longer, the ninth as broad as the eighth and forming with the two last segments a narrow, elongate clava, terminating in an acute point, a little flattened and at their articulations rather serrate rendering at least very doubtful the independent mobility of the tenth and eleventh segments. Thorax narrow and elongate, disk depressed and narrowed in front, sides feebly dilated, front and hind margins equal in width, anterior coxal cavities open behind. Elytra depressed, much broader than base of thorax, very elongate parallel, but not reaching to apex of the abdomen, suture closed, irregularly rounded at apex, surface rather smooth (in the typical species sometimes seriately punctate). Legs elongate, thin, the posterior pair twice as long as the others, their femora reaching beyond the apex of the elytra, tibiæ rather longer than the femora, straight and cylindrical, tarsi very long, five-segmented, equally visible, long and narrow, the posterior having the two first elongate conical, the first shorter than the second by about one-third, third and fourth short, bifid, lamellate beneath, the second longer than any of the others, subequal to segments three and four united, and somewhat similarly depressed, a little dilated and feebly emarginate at apex, the fifth segment shorter than either of the preceding two, terminated by two large and short simple ungues, all tarsi pubescent beneath.

Genotype.—*Evenus filiformis* Cast. Monobasic.

Geographical range, thirteen species all of Madagascar.

Genus LASIOCALLIMERUS Corporaal

Lasiocallimerus Corporaal, Tijds. v. Ent., 82, 1939, p. 194.

Diagnosis of *Lasiocallimerus* Corporaal

"*Tarsorum articulo primo longiore quam secundo. Statura generi Brachycallimero similis, sed antennæ 10-articulatæ, arti-*

culo robusto, articulo secundo æque crasso, paulo breviore, articulo tertio subelongato, articulis 4–9 transversis, articulo ultimo subelongato, ovato, ad apicem subacuminato. Corpus longe pilosum et, in thorace, dense squamuloso-villosum. Pedes quales in genere Brachycallimero, tibiis sine tuberculo, tarsis latis, unguiculis latis, ad apicem emarginatis.

"With the first tarsal segment longer than the second. Head broad; eyes [rather large] very prominent, [finely facetted, with long, erect, pale hairs] very slightly emarginate near antennal socket, labrum entire, mandibles broad and flat, falcate. Antennæ short and compact, ten-segmented; first segment short and stout, second of equal thickness, but shorter, third a little longer than broad, fourth to ninth broader than long, tenth longer than broad, ovate, a little acuminate. Prothorax of the same form as in *Brachycallimerus*, heavily punctate, under the longer pilosity closely covered with crisp, scale-like hairs. Elytra broader than prothorax, evenly punctured, but not in rows. Abdomen with six visible ventral segments. Legs of moderate length, tibiæ without notch, tarsi short and broad, claws broad, emarginate at tip" (Corporaal).

Genotype.—*Lasiocallimerus vestitus* Corp., designated by Corporaal.

Geographical range, one species of Java.

Genus ALLELIDEA Waterhouse

Allelidea Waterhouse, Trans. Ent. Soc. Lond., II, 1839, p. 193. —Lacordaire, Gen. Col., IV, 1857, p. 473.—Chenu, Encycl. d'Hist. Nat., Col., II, 1860, p. 266.—Gorham, Trans. Ent. Soc. Lond., 1877, p. 263.—Blackburn, Trans. Roy. Soc. South Austral., XIV, 1891, p. 302.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 97.—Gahan, Ann. Mag. Nat. Hist., (8) V, 1910, p. 65.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 112.

Diagnosis of *Allelidea*, revised

Body elongate, cylindrical. Head with the eyes as broad or broader than the thorax, constricted posteriorly, front verticle, labrum transverse, emarginate. Terminal segment of maxillary palpi ?, that of labial palpi oblique, securiform. Mandibles in-

ternally with a small tooth before the apex. Eyes moderately prominent, entire. Antennæ very short, eleven-segmented, articulations very distinct, segments very small, gradually growing larger, the three last segments slightly larger than the others forming a very lax elongate-oblong clava. Thorax longer than broad, narrow and elongate, subcylindrical, sides a little before the middle roundly dilated, at bast strongly narrowed. Elytra not much broader than thorax at base, seriately punctured, elongate, gradually and very feebly broader posteriorly, apex serrate, as long as the abdomen (♂ ?), or much shorter (♀ ?). The three pairs of legs equal in length, long and slender, posterior femora slightly shorter than the abdomen, tarsi five-segmented, first segment not much longer than the succeeding segments together, segments two to four with bilobed membraneous appendices, fifth segment moderate. Ungues with membraneous appendices.

This is a small insect with the facies of *Phyllobænus*.

Genotype.—*Allelidea ctenostomoides* Waterh., designated by Gorham.

Geographical range, seven species of Australia.

Remarks on genera more or less allied to the genera of the subfamily Phyllobæninæ, or transferable to that subfamily.

Genus BRACHYPTEVENUS Pic

Brachyptevenus Pic, Mél. Exot.-ent., LXXI, 1939, pp. 24–25.

Diagnosis of *Brachyptevenus,* revised

Head broader than the thorax, posteriorly long attenuate, not strangulate. Thorax elongate, sides sinuate, middle impressed posteriorly. Elytra but little reduced, anteriorly subattenuate, narrow and elongate, apex slightly broader. Legs slender, abdomen distinctly exceeding the elytral apex. This new genus is near *Evenus* Cast. It is clearly characterized by the form of the head and the elytra. It is established for the following new species *B. niger* Pic.

Genotype.—*Brachyptevenus niger* Pic. Monobasic.

Geographical range, 1 species of Madagascar.

The writer has been compelled by reason of the brief and unsatisfactory diagnosis of this genus to omit it from consideration in the body of this account.

Genus ACHLAMYS Waterhouse

Achlamys Waterhouse, Cist. Ent., II, 1875–1882 (1879), p. 530.—Schenkling, Gen. Ins., (Wytsman) Cler., 1903, p. 16.—Schenkling, Col. Cat., (Junk) Cler., 1910, p. 17.

Diagnosis of *Achlamys*, revised

Form cylindrical. Head (with the eyes) broader than the thorax, the eyes prominent, coarsely granulate, scarcely emarginate in front. Antennæ as long as the head and thorax taken together, the first segment thick, ovate, the second segment small, the third elongate, subcylindrical, the fourth, fifth and sixth becoming gradually stouter and shorter, the seventh as broad as long, the eighth, ninth, tenth and eleventh segments forming a distinct four-segmented clava. Apical segment of the maxillary palpi elongate, a little narrowed before the apex; apical segment of the labial palpi securiform. Prothorax very convex, one-third longer than broad, very slightly constricted before the front margin, strongly constricted before the base. Elytra parallel, a little broader than the thorax, each with seven lines of deep oblong punctures which do not extend quite to the apex, which is smooth and obtuse. Tarsi with five distinct segments, the ungues with a single tooth at the base.

"Closely allied to *Pallensis*, but with prominent eyes and distinct club to the antennæ" (Waterhouse).

The writer believes *Achlamys* should be removed from Tillinæ to the Phyllobæninæ and there with *Paupris* Sharp, both genera having coarsely facetted eyes, a character exceptional in this subfamily, these two genera may be placed as a distinct group or tribe designated by the term Pauprini.

Gahan (1910: 65) has transferred the genus *Ellipotema* Spinola to the subfamily Corynetinæ, and the genera *Cleropicstus*, *Calendyma* Lac., and *Epiclines* Chevr., to the subfamily Clerinæ, he also briefly differentiates (*loc. cit.*, p. 64) the genus *Epiclines* and *Eurycranus* (= *Eurycranium* Blanch.) and calls attention to the long-standing and absolutely absurd erroneous synonymy which has been perpetuated ever since the issuance of Lacordaire's Genera des Coléoptères. Of the species in our Catalogues under *Epiclines* only a few, as far as can now be determined,

really belong to that genus, those that should be so placed are as follows: *gayi* Chevr., (nec Spin.), *ænea* Phil., *basalis* Blanch., *puncticollis* Spin., *ruficollis* Phil., *similis* Schklg., *advena* Chevr., *viridis* Phil., and probably *tristis* Spinola. The rest of the listed species with scarcely an exception should go to the genus *Eurycranium* Blanchard.

Genotype of *Epiclines*, *E. gayi*, Chevrolat. Monobasic.

Geographical range, Chile.

The genera of this subfamily may be grouped according to natural characters as follows:

Group 1

Clava two-segmented; basal segment of hind tarsi short, covered above by the second segment, prothorax variously proportioned.

Phyllobænus Dejean, *Lemidia* Spinola, *Isohydnocera* Chapin.

Group 2

Clava indefinitely two- or three-segmented; basal segment of hind tarsi short, covered above by the second segment, prothorax with length and breadth subequal.

Wolcottia Chapin, *Parmius* Sharp, *Neohydnus* Gorham, *Metaxina* Broun.

Group 3

Clava three-segmented; basal segment of hind tarsi short, covered above by the second segment, prothorax with length usually greater than breadth.

Abrosius Fairmaire, *Cephaloclerus* Kuwert, *Eurycranium* Blanchard, *Paupris* Sharp, *Isolemidia* Gorham.

Group 4

Clava two-segmented; basal segment of hind tarsi long, not covered by the second segment, prothorax as long as broad.

Emmepus Motchoulsky.

Group 5

Clava three-segmented; basal segment of hind tarsi long, not covered by the second segment, prothorax at least as long as broad.

Theano Castelnau, sub. gen. *Callimerus* Gorham, sub. gen. *Cucujocallimerus* Pic.

Group 6

Clava five-segmented; basal segment of hind tarsi long, not covered by the second segment, prothorax broader than long.
Sub. gen. *Brachycallimerus* Chapin.

Group 7

Clava indistinctly four-segmented; basal segment of hind tarsi long, not covered by the second segment, prothorax longer than broad.
Evenus Castelnau.

Group 8

Clava one-segmented; basal segment of hind tarsi long, not covered by the second segment, prothorax broader than long.
Lasiocallimerus Corporaal.

Group 9

Clava indistinctly three-segmented; basal segment of hind tarsi long, prothorax longer than broad.
Allelidea Waterhouse.

BIBLIOGRAPHY

BEDEL, L.
1887. Recherches sur les Coléoptères du nord de l'Afrique. Recherches synonymiques. Ann. Soc. Ent. Fr., (6) VII, p. 195–202.

BLACKBURN, T.
1889. Further notes on Australian Coleoptera, with descriptions of new genera and species. Proc. Linn. Soc. New South Wales, (2) III, p. 1387–1506.
1891. Further notes on Australian Coleoptera, with descriptions of new genera and species: X. Trans. Roy. Soc. South Australia, XIV, p. 292–345.

BLANCHARD, ÉMILE.
1844. Voyage dans l'Amérique méridionale de M. Alcide d'Orbigny, VI, 1837–1844 (1844). Insectes, p. 1–222. Paris.
1845. Histoire des Insectes, traitant de leurs mœurs métamorphoses en général et comprenant une nouvelle classification fondée sur leurs rapports naturels, II. Paris.
1853. Voyage au pole sud et dans l'océanie sur les corvettes l'Astrolabe et la Zélée; etc. Zoologie, IV, Description des Insectes, p. 59–65. Paris.

BOHEMAN, CARL H.

1851. Insecta Caffrariae annis 1838–1845 J. A. Wahlberg collecta amici auxilis suffultus, Coleoptera, I, fasc. 2, p. 299–626. 3 pls. Holmiæ.

BRADLEY, J. CHESTER.

1930. Manual of the genera of beetles of America north of Mexico. New York.

BROUN, THOMAS.

1880. Manual of New Zealand Coleoptera, I, p. 330–337. Wellington.

1909. Descriptions of new genera and species of New Zealand Coleoptera. Ann. Mag. Nat. Hist., (8) III, p. 385–415.

CASTELNAU, COMTE FRANCIS DE LAPORTE.

1936. Études entomologiques ou descriptions d'insectes nouveaux et observations sur la synonymie. Silb. Rev. Ent., IV, p. 5–60.

CHAGNON, GUSTAVE.

1935. Coléoptères de la province de Québec. Nat. Canad., LXII, p. 165–175.

CHAPIN, EDWARD A.

1917. Studies in the Hydnocerini—The Hydnoceroid Genera. Bull. Brookl. Ent. Soc., XII, p. 83–85.

1920. New American Cleridæ, with note on the synonymy of Micropterus Chevr. (Col.). Proc. Ent. Soc. Wash., XXII, p. 50–54.

1922. New North American Hydnocera. Proc. Biol. Soc. Wash., XXXV, p. 55–58.

1924. Classification of the Philippine components of the Coleopterous family Cleridæ. Philipp. Jour. Sci., XXV, 2, p. 159–286. pls. 1–5.

CHENU, JEAN CHARLES.

1860. Encyclopédie d'histoire naturelle ou traiite complet de cette science d'apres les travaux des naturalistes les plus eminents, etc. Coleoptera, II, p. 1–312, pls. Paris.

CHEVROLAT, LEON AUGUSTE.

1829. Les Insectes. Les Coléoptères. Troisème famille.—Les Serricornes. Guérin's Iconographie du Règne Animal de Cuvier. Insectes, partie VII. 1829–1838. Paris.

1843. Description de vingt-quatre nouvelles espèces de Térédiles pour faire suite a la Monographie des Clairones de M. le Docteur Klug. Ann. Soc. Ent. Feance, (2) I, p. 31–42.

1874. Catalogue des Clérides de la collection de M. A. Chevrolat. Rev. Mag. Zool., (3) II, p. 252–329.

1876. Mémoire sur la Famille des Clérites. pp. 1–51. Paris.

CORPORAAL, J. B.

1937. A New Brachycallimerus from Java. Rev. Française d'Entom., IV, p. 60–62.

1939. Studies in Callimerus and allied genera. (Col.). Tijd. v. Ent., LXXXII, p. 182–195.

DEJEAN, COMTE PIERRE FRANCOIS M. A.
1837. Catalogue des Coleopteres de la collection de le baron Dejean. Edit. 3, corrected and augmented, p. 1–503.
ESCHSCHOLTZ, JOHANN F.
1831. Voyage du capitainne Kotzebue. Zoologischer Atlas, IV, fasc. 2, pl.
FAIRMAIRE, LEON.
1883. Emmepus Bonnairei. Compt. rend. Soc. Ent. Belg., XXII, p. 157.
1902. Description des Clérides recuillis par le Dr. Decorse dans le Sud-est de Madagascar. Bull. Mus. Hist. Nat., VIII, p. 306–317. Paris.
FAIRMAIRE, LEON, ET GERMAIN, P.
1861. Coleoptera Chilensis, II, p. 1–4. Paris.
FURSOV, N. I.
1936. Eine neue Gattung und 5 neue arten aus Fam. Cleridæ (Coleoptera) von Ost-Sibirien und Mittelasien. Bull. Soc. Nat. Moscou, Sect. Biol., Nouvelle serie, XLV, 5, p. 351–354.
GAHAN, CHAS. J.
1902. Observations on some mimetic insects and spiders from Borneo and Singapore, with appendices containing descriptions of New Species by ———— and C. J. Gahan. Proc. Zool. Soc. Lond., II, p. 250–284, pl.
1910. Notes on Cleridæ and descriptions of some new Genera and Species of this Family of Coleoptera. Ann. Mag. Nat. Hist. Lond., (8) V, p. 55–76.
GEMMINGER, MAX.
1870. Epiclines spinolai. Col. Hefte, VI, p. 127.
GEMMINGER, MAX., ET HAROLD, EDGAR VON.
1869. Catalogus Coleopterorum Hucusque descriptorum synonymicus et systematicus, VI, p. 1722–1759.
GERMAR, ERNST FRIEDRICH.
1824. Insectorum species novae aut minus cognitae, descriptionibus illustratrates. Volumen primum. Coleoptera, p. 80–81.
GORHAM, HENRY STEPHEN.
1876. Notes on the Coleopterous family Cleridæ, with descriptions of new genera and species. Cist. Ent., II (1875–1882), p. 57–106.
1877. Descriptions of new species of Cleridæ. Trans. Ent. Soc. Lond., p. 245–263.
1877. Descriptions of new species of Cleridæ, with notes on the genera and corrections of synonymy. Trans. Ent. Soc. Lond., p. 401–426.
1878. Descriptions of new genera and species of Cleridæ, with notes on the genera and corrections of synonymy. Trans. Ent. Soc. Lond., p. 153–167.

1882. Malacodermata. Cleridæ. Biol. Centr.-Amer., III, pt. 2, 1882–1883, p. 129–193. Suppl., 1886, p. 332–346, 13 pls.

1892. Viaggio di Leonardo Fea in Birmania e regioni vicine, xlviii, Cleridæ. Ann. Mus. Genov., (2) XII, p. 718–746.

HAROLD, EDGAR VON.

1879. Genus Thereutes. Col. Hefte, XVI, p. 248–249, nota.

HINTZ, E.

1905. Neue Cleriden aus Westafrika. Deutsch. Ent. Zeitsch., II, p. 305–314.

KLUG, JOHANN C. F.

1842. Versuch einer systematischen Bestimmung und Auseinandersetzung der Gattungen und Arten der Clerii, eine Insectenfamilie aus der Ordnung der Coleopteren. Abh. Konigl. Akad. Wiss. Berlin, p. 259–397, 2 pls.

KRAATZ, GUSTAV.

1899. Verzeichniss der von Hrn. Conradt in Westafrica (Kamerun, Togo) gesammelten Cleriden. Deutsch. Ent. Zeitschr., p. 81–107.

KUWERT, A.

1893. Neue Africanische Cleriden. Ann. Soc. Ent. Belg., XXXVII, p. 486–497.

LACORDAIRE, JEAN THEODORE.

1857. Histoire naturelle des Insectes. Genera des Coléoptères, ou exposé méthodique de tous les genres proposés jusqu'ici dans cet ordre d'Ínsectes, IV, Clérides, p. 415–496. Paris.

LEA, ARTHUR M.

1907. Notes on the genus Lemidia with descriptions of new species. Ann. Soc. Ent. Belg., LI, p. 331–362, 2 pls.

LECONTE, JOHN LAWRENCE.

1849. Synopsis of the Coleopterous insects of the group Cleridæ which inhabit the United States. Ann. Lyc. Nat. Hist. N. Y., V, p. 9–35, pp. [1–27 of reprint].

1861. Classification of the Coleoptera of North America. Pt. 1. Smiths. Misc. Coll., III, p. 1–208 issued 1861, p. 209–278 issued 1862.

LECONTE, JOHN L., AND HORN, GEORGE HENRY.

1883. Classification of the Coleoptera of North America. Smiths. Misc. Coll., XXVI, No. 507, p. i–xxxviii + 1–567. Washington.

LESNE, PIERRE.

1909. Notes sur la nomenclature des Clérides (Col.). Bull. Soc. Ent. France, p. 206.

MOTSCHOULSKY, T. VICTOR VON.

1845. Remarques sur la collection de Coléoptères russes de Victor Motschoulsky. Bull. Soc. Imp. Nat. Moscou, XVIII, No. 1, p. 1–127, pl. 3.

1861. Essai d'un cat. des Ins. de l'Ile Ceylan. Bull. Soc. Imp. Nat. Moscou, XXXIV, p. 125–127.

NEWMAN, EDWARD.

1837. Entomological notes. Entom. Mag. London, p. 372–402.

1840. Descriptions of new species of Coleopterous insects. Mag. Nat. Hist., (2) IV, p. 362–368.

1841. Entomological notes. The Entomologist, 1840–1842, p. 1–37. London.

1843. On new species of Coleoptera. The Zoologist, I, 1843–1861, p. 1–384. London.

PASCOE, FRANCIS P.

1860. Notes on little known genera and species of Coleoptera. Jour. of Entom., I, p. 36–64.

1876. Descriptions of new genera and species of New Zealand Coleoptera, Pt. 2. Ann. Mag. Nat. Hist., (4) XVII, p. 48–60.

PHILIPPI, R. A. ET FRIEDR.

1864. Beschreibung einer neuen Chilenischen Käfer. Stett. Ent. Zeitung, p. 266–284.

PHILIPPI, RODULFO AMANDO.

1865. Description de algunos insectos nuevos chilenos por don Rodulfo Amando Philippi. Ann. Univ. Chila, XXVI, p. 651–660.

PIC, MAURICE.

1927. Coléoptères du Globe. Mél. Exot.-ent., L, p. 1–36.

1929. Genera allied to Callimerus. Mél. Exot.-ent., LIV, p. 16–17.

1939. Mutations et nouveautes diverses. Mél. Exot.-ent., LXXI, p. 1–36.

REITTER, EDMUND.

1894. Bestimmungs-Tabelle der Coleopteren-Familie der Cleriden, des palæarctischen Faunengebietes. Verh. Naturf. Ver. Brunn., XXXII, 1893 (1894), p. 37–89.

1894. Bestimmungs-Tabelle der Coleopteren-Familie der Cleriden. Heft XXVIII, p. 1–56.

1896. Hydnocera—Emmepus. Wien. Ent. Zeit., XV, p. 283.

SAY, THOMAS.

1823. Descriptions of Coleopterous insects collected in the late Expedition to the Rocky Mountains, performed by order of Mr. Calhoun, Secretary of War, under the command of Major Long. Jour. Acad. Nat. Sci. Phila., III, p. 139–216.

1825. Descriptions of new Coleopterous insects inhabiting the United States. Jour. Acad. Nat. Sci. Phila., V, p. 160–204.

SCHENKLING, SIGMUND.

1898. Revision der Cleridengattung Lemidia Spin., nebst Beschreibung einiger neuer Arten. Deutsche Ent. Zeit., I, p. 169–182.

1901. Neue Cleriden des Koniglichen Museums zu Brüssel. Ann. Soc. Ent. Belg., XLV, p. 104–108.

1902. Clériden nouveaux du Muséum naturelle de Paris. Bull. Mus. Hist. Nat., VIII, p. 317–332.

1903. Genera Insectorum. Coleoptera Malacodermata. Fam. Cleridæ. (Wytsman), fasc. 13, p. 1–124, 5 pls. Bruxelles.

1908. Some Cleridæ of the Indian Museum. Rec. Ind. Mus., II, pt. 4, 387–388.

1910. Coleoptera Catalogus. Auspiciis et auxilio W. Junk editus a S. Schenkling, pars 23, Cleridæ. Berlin.

SCHÖNHERR, CARL J.

1840. Genera et species Curculionidum, VI, pt. 1, p. 1–174. Paris.

SHARP, DAVID.

1877. Description of some new genera and species of New Zealand Coleoptera. Entom. Month. Mag., XIII, p. 271–272.

SPINOLA, MARQUIS MAXIMILIEN.

1841. Monographie des Térédiles. Tableau synoptique des Clairons. Rev. Zool. por la Soc. Cuvier., p. 70–76. Paris.

1844. Essai Monographique sur les Clérites insectes coléoptères, I, II and Suppl., 47 pls. Gênes.

1849. in Claudio Gay: Historia fisica y politica de Chile, Zoologia, IV, Cleroideos, p. 381–414, 1 pl. Paris.

THOMSON, JAMES.

1860. Matériaux pour servir a une monographie nouvelle de la famille des Clérides. Musée scientifique ou recueil d'histoire naturelle, p. 46–67.

WATERHOUSE, CHARLES OWEN.

1879. New species of Cleridæ and other Coleoptera from Madagascar. Cist. Ent., 1875–1882, p. 529–534.

WATERHOUSE, GEORGE ROBERT.

1839. Descriptions of some new species of exotic insects (Coleopt., Hymenopt.). Trans. Ent. Soc. Lond., II, p. 188–196, fig.

WESTWOOD, JOHN OBADIAH.

1852. Descriptions of new Cleridæ from Asia, Africa and Australia. Proc. Zool. Soc. Lond., XX, p. 35–55 (Annulosa), pls. 24–27.

WHITE, ADAM.

1849. Nomenclature of Coleopterous insects in the collection of the British Museum, pt. IV, Cleridæ, p. 1–68. British Museum, London.

WICKHAM, HENRY FREDR.

1895. The Coleoptera of Canada, 13. The Cleridæ of Ontario and Quebec. Can. Ent., XXVII, p. 247–253, 4 text figs.

WOLCOTT, ALBERT BURK.

1910. The Cleridæ of Indiana, in Blatchley, Col. Ind. Bull 1, Dept. Geol. Nat. Res., p. 846–862.

1910. Reprint of the above title issued separately.

1910. Notes on some Cleridæ of Middle and North America with descriptions of new species. Field Mus. Publ. Zool., VII, p. 339–401.

THE REPRODUCTIVE FUNCTIONS OF THE ARMY-ANT QUEEN AS PACE-MAKERS OF THE GROUP BEHAVIOR PATTERN

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Although they are among the commonest ants encountered in the tropical forests of the Old and New Worlds, the dorylines have long remained among the least known. In Africa and Asia the "driver ants" and in tropical America the "legionary" or "army" ants of this subfamily present many intriguing problems, especially in the predatory raids and nomadic life of their colonies and the biological status of their huge wingless fertile females, the dichthadiigynes. These last individuals are not very well known to science, since up to a relatively short time ago virtually no precise information was available concerning their relations to the colony. Actually we find, beyond propagative functions which differ rather strikingly in some respects from those of fertile females in other insects, the properties of the doryline queen make her a factor of critical importance in the general process of colony behavior.

This paper is directed toward accounting for the essential ontogenetic basis of the behavior pattern characteristic in the subgenus *Eciton s. str.*, an American branch of the subfamily Dorylinæ. Our study specifically concerns these terrestrial army ants, especially the type species of the subgenus, *E. hamatum*. The results may prove eventually to have relevance among the dorylines far beyond the conditions of the species on which this report is based.[2]

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The chief characteristics of the behavior pattern of *E. hamatum* involve the formation of bivouacs, raiding, and bivouac-change movements which in series may be termed migrations. In this species the temporary nest or bivouac of a given colony is a more or less cylindrical mass formed by the clustered bodies of ants alone, without foreign materials, usually depending from a log or vines, or hanging against a tree. From his studies in the rainy season the writer (1933; 1938) has described two distinctive conditions through which colonies of *E. hamatum* pass successively in alternation at such times: the *nomadic* and the *statary* activity phases. Roughly, each phase lasts close to 20 days before it is succeeded by the other. The principal characteristics of the nomadic phase are 1) highly developed daily raids and 2) a regular change of the bivouac site at the termination of each day. In rather sharp contrast, the statary phase is marked by 1) less developed raids and 2) occupancy of the same bivouac site throughout the interval. In addition there are other features which characterize each of these behavior phases. These are essentially intrinsic to the colony, yet as we shall find they are intimately involved in the entire system of events in Eciton behavior.

Our essential hypothesis is that a close relationship exists between behavior outside the bivouac (*i.e.*, raiding and bivouac-change processes) and conditions within the bivouac, and that this pattern of events basically depends upon the functions of the reproductive agent of the colony. Accordingly in this paper attention focusses upon the rôle of the mother queen, whose properties apparently are of key importance in the entire mechanism of the Eciton behavior pattern.

Material for this study was gathered and most of the field observations were carried out on Barro Colorado Island in the Panama Canal Zone, in the rainy season months of 1936 and 1938 (May to September). In that locality the rainy period usually begins in April and ends in early December. Investigations of the Eciton problem have yet to be conducted in the dry season. This limitation is important, since it is very probable that rainy-season conditions are optimal for the appearance of relationships such as we shall describe. In an indirect manner the results of this study suggest that with extreme changes in prevalent atmos-

pheric conditions important variations may occur in the described behavior pattern. In view of this, it is a fact of some importance that our evidence was gathered in a portion of the Caribbean lower rain-forest zone in which the rainy and dry seasons are differentiated rather sharply from year to year. What differences will be found under more variable meteorological conditions represent an interesting problem.

PROPERTIES OF THE ECITON QUEEN

From the time André (1885) captured the first dichthadiigyne from the subterranean bivouac of an *E.* (*Labidus*) *coecum* colony the list of captures has grown very slowly, and although fertile females are at present known from nearly 25 of the more than 100 recorded species of *Eciton* and all of the eight recorded species of *Eciton s. str.* (Bruch, 1934), they are still among the most highly prized collector's items. In view of the great difficulty of capturing them, it is scarcely surprising that these rare insects have been almost invariably clapped into alcohol when taken, under the influence of what Creighton has appropriately termed "collector's itch." This practice of course has not precluded the accumulation of much valuable information concerning the external morphology and the taxonomic affinities of the specimens; yet it has unfortunately kept in the remote background several important questions which can find their answers only in study of the living queen.

Thus it is unfortunate that from the records of more than a score of collections very little can be learned about the behavior and biological properties of the living individual. With the exception of general observations carried out by Wheeler (1900) with captive colonies of *E. schmitti* in Texas, no special investigations have been attempted. The present study stems from a general investigation of army-ant behavior which has revealed the probability that the dichthadiigyne plays a crucial though indirect rôle in the phenomena of Eciton behavior (Schneirla, 1934; 1938).

Eciton queens may be found in either of two very different conditions, the "normal" or contracted condition and the physogastric or egg-producing condition (see Fig. 1). For the present study, the dichthadiigyne material comprised 13 queens of *E.*

hamatum and one of *E. burchelli* in the contracted condition, and one queen of *E. hamatum* in the physogastric condition. In each case, field notes on the colony from which a given queen was taken covered the general situation of the colony and its behavior (especially its raids and bivouac-change movements) over a period of days, the status of the brood or broods and the condition of the queen at the time of capture. Each queen was kept alive in the laboratory as long as possible after capture, for observation and test both alone and in relation to the workers of her colony.

There is a notable disparity in our material as to condition of the queen when captured. Why so many of the cases were in the contracted condition and only one case physogastric when taken will become clear as the general circumstances of Eciton life are disclosed.[3] For a number of reasons, physogastric army-ant queens are exceedingly difficult to capture. There is only one other case on record in which such an individual was observed during her short span of life in captivity, that of a physogastric queen of *E.* (*Labidus*) *coecum* taken by Weber (1941) in Trinidad. Fortunately we are not forced to depend upon direct evidence concerning the queen at all stages, since an abundance of other evidence coordinates nicely with results derived from work on the queen herself.[4]

A descriptive contrast of queens and workers.—The Eciton queen (Fig. 1) stands out as strikingly unique among fertile insect individuals and as a highly distinctive member of her colony. We may use the queen of *E. hamatum* as example.[5] Unlike the queens of virtually all other ants, she is wingless *throughout life.* In color she is almost uniformly ferrugineous mahogany, darker than the yellowish brown which characterizes the workers, and lacks the cephalic paleness of major workers. She differs strik-

[3] It is a striking fact that among 16 captured queens representing ten *Eciton s. str.* species and sub-species, reported by various authors prior to 1942 (see *e.g.*, Wheeler, 1921; Bruch, 1934), *all* were in the contracted condition.

[4] In the present paper the supporting evidence is reported rather concisely. Further details and additional evidence will be incorporated in a monograph on this subject, now in preparation with the collaboration of Dr. Harold R. Hagan of the Department of Biology, City College of New York.

[5] The reader is referred to Wheeler's systematic descriptions of the first queens of *E. hamatum* (1925) and *E. burchelli* (1921) to be discovered.

ingly from the workers in gross size and in anatomical detail. The greater bulk of the queen is suggested by the fact that her over-all length (contracted) is close to 17.1 mm. (Av. 6 specimens), whereas the range of body length in the workers is 2.5 mm. (minor) to 9.5 mm. (major). The polymorphic worker types resemble the queen only very broadly, for example both queen and workers possess well-developed and dentate tarsal claws, near the inferior occipital corners of the queen's head there are small obtuse projections homologous to the acute spines of the worker major, and the queen possesses strikingly prominent pairs of epinotal and petiolar horns contrasting with two simple aligned nodes in the worker. Among many impressive morphological differences are the large lateral pseudo-ocelli (Werringloer, 1932) of the queen and the relatively tiny ones of workers, the great bulk of the queen's thorax and her well-developed legs as contrasted with corresponding slenderness in the worker's structures, and in particular the great size of the queen's abdomen contrasted with the much smaller gaster of the worker. Associated with an enormous expansion of reproductive functions in the queen and the probable absence of such functions in the worker, the hamatum queen's gaster even when contracted measures near 9.1 mm. in length and 5.5 mm. in its greatest width, whereas the gaster of the largest major worker measures only 2.6 mm. in length and 1.8 mm. in width. The queen's gaster terminates distinctively in a large triangular shelf, the hypogynium. Another striking characteristic of the queen is the marked development of her external respiratory orifices or stigmata, suggesting a high stage of development in the respiratory system generally.

This general morphological comparison may suffice to illustrate the extent to which the Eciton queen diverges from the workers, paralleling a functional specialization which correspondingly differs markedly from that of the workers. The nature and extent of the dichthadiigyne's specialization becomes clear when we consider some typical characteristics of her behavior and her place in the life economy of the colony.

Behavior and functional properties of the "normal" or contracted queen.—In *E. hamatum* and probably in *Eciton s. str.* generally the reproductive capacity of any given colony is cen-

tered in a single individual, a fecund dichthadiigyne. A selective mechanism of some kind evidently is involved which excludes additional queens, possibly at a time shortly before or after young queens are fertilized. Circumstances indicate that this one fecund individual must pass around nine-tenths of her days in the rainy season in the resting or contracted condition, which as a consequence may be termed her "normal" state. Ordinarily she

FIG. 1. Queens of *E. hamatum* in the contracted (upper) and the physogastric or gravid condition. (*Cf.* Fig. 2 and Table I.) Total length of the contracted queen, 17 mm. (Drawing by Miss Janet Roembild, from photographs by Dr. Virgil Argo, Dept. of Biology, City College of New York.)

does not leave the confines of the bivouac, except when she is drawn into a bivouac-change movement, an event that scarcely ever engages her before nightfall.

Circumstances indicate that the sequestration of the queen may be due largely to the effect which light exerts upon her. In laboratory tests she reacts specifically to directionalized bright light

by turning away from the source and moving energetically about until in darkness. Whenever she chances into the light, facing toward the source, the queen volte faces abruptly and runs off. (Among numerous observations, this test was repeated in one instance 12 times in 30 minutes with the same queen,—always with the described result.) When illumination is not intense the response is more variable, yet even then as a rule the queen settles down only when in a fairly dark part of the nest.

In contrast to the queen, the workers seem virtually incapable of specific orienting responses to light. They are aroused to activity by light after a period of darkness; thus colonies are regularly stimulated to begin their daily raiding after dawn (Schneirla, 1938; 1940). This however is a mere photokinetic effect (*i.e.*, a generalized excitation by light), and they appear incapable of orienting to directionalized illumination except in a very crude fashion as an outcome of restless movements over a considerable time. That the basis of this outstanding difference between queen and workers rests in different optoneural equipment is suggested by the fact that in *E. hamatum* the gross size of the queen's lateral pseudo-ocellus is more than twice that of the major worker's. We should expect to find correspondingly accentuated differences in the internal structure of the visual receptor, and in related mechanisms, underlying the queen's pronounced normal reactivity to light.[6]

This recalls the fact that the fertilized queens of ants in general are repelled by light. Whether the Eciton queen, like any others, is positive to light prior to fertilization cannot be said at present; however, the sharpness of the functional queen's avoidance response is clear. The basis of a highly adaptive circumstance is thereby provided—that the queen is cloistered in a well-protected situation except when the colony shifts its home site. The prevalence of this condition is attested by the fact that Eciton queens are never seen at other times, as during raids—its effectiveness is emphasized by the difficulties one experiences in capturing these queens.

[6] Although no queen material was available for Werringloer's (1932) valuable histological study of Eciton visual mechanisms, species differences were found in optic histology which appear to parallel typical behavior differences.

That the queen keeps to the bivouac in the daytime, during raids, is not attributable to any inability to follow the colony's trails. In the laboratory, captive hamatum queens may run for hours at a time in a column following a circular path established by workers or, when one is set down near a vacated trail of her own colony in the forest, she follows the route successfully once she hits upon it. Evidently it is her "photophobic" proclivities that mainly account for the queen's sequestration in the bivouac.

Although for a long time the idea has held sway that the army-ant queen is moved passively about by the workers when the colony shifts its site, in *Eciton s. str.* the facts are contrary to this supposition. In laboratory nests the queen readily makes her way about despite the usual added burden of several workers hitch-hiking and dragging from her legs or gaster. The physical characteristics of her well-developed legs give every indication of great strength, as does her robust frame in general—an impression borne out fully by her behavior. The test comes during the long bivouac-change march in the wild when the queen must make her way over a route generally much longer than 100 meters, passing along a narrow and tortuous trail full of hazards such as vine bridges and sharp turns although she is swarmed under at nearly every step by a frenzied crowd of workers.

On a number of occasions the hamatum queen's participation in the colony movement has been observed, always at night except in two instances when colonies were greatly oversize and the movements unduly extended. The bivouac-change usually gets under way before dusk and is completed during the night, with the queen coming along during the latter part and frequently near the very end of the trek. The explanation seems to be that she is normally stationed in the innermost recesses of the cluster, centered in the brood with a mass of workers minor around her, in a section of the bivouac which is likely to be almost the last to be drawn into the evacuation.

Just before the queen appears from the bivouac there is a very noticeable increase in excitement among the workers on the trail, agitated variable movement becomes common instead of the monotonous plodding seen previously, and the column begins to widen perceptibly from the 2–3 cm. which is characteristic. As

the column becomes more crowded it broadens to as much as 15 cm. within a few minutes, then the queen appears in the thickest part. As the queen moves along she is not only surrounded by jostling workers of all sizes, but much of the time is literally covered with them, has them underfoot and hanging to her. The workers hamper her movements particularly when she slows in mounting steep grades or in rounding sharp corners; at such times they may crowd around so that she is actually stopped for a time. The remarkable fact is that amid this great excitement and arduous labor the queen is able to follow the trail in its devious windings and through its difficult sections.[7] Tests show that this ability depends upon a response to Eciton chemical. For example, if the queen is taken up and returned to the route when there are no workers upon it, she follows it readily. There can be little doubt about the fact that the queens of *Eciton s. str.* participate quite actively in the bivouac-change movements of their colonies and get to the new site under their own power.

The adaptive significance of the workers' behavior toward the queen during the lengthy migratory trek deserves mention. Since at all times a high pitch of excitement is maintained in the queen's section of the march, any intrusion is immediately responded to by large numbers of frenzied workers so aroused that they bite and sting with very little provocation. In the darkness of night, the feverish activity that prevails in the few meters of column near the queen contrasts strongly with the lethargic monotonous lock-step movement that prevails throughout the other sections of the movement. Only in the entourage of the queen are the workers aroused to a degree of excitement and responsiveness that resembles their daytime activity in raiding. The outcome is that the colony's reproductive specialist is well protected at the time when exposure is great.

The strength and vitality of the queen are shown impressively when the colony is etherized for capture. Because of the agility and speed with which she is capable of moving when disturbed, the queen generally is able to make her escape from the bivouac while the principal mass of workers succumbs to the anaesthetic.

[7] Reichensperger (1934) observed similar occurrences in a bivouac-change movement of an *E. lucanoides* colony in Costa Rica from which he captured the queen.

Thus she is frequently discovered under a leaf or piece of bark near the outer edge of the sheet used to imprison the bivouac, still somewhat active although workers in numbers lie prone around her, and if the way is not blocked she may make good her escape along a raiding trail.

Wheeler (1921) has remarked upon the possibility that an extensive development in the respiratory system of the Eciton queen is an important adaptation to a sequestered bivouac life. The pronounced development of this system in general is indicated by the prominence of the spiracles, the external openings of the breathing tubes. With a highly efficient mechanism for gaseous exchange, it is possible for the queen, despite her huge bulk and relatively great oxygen needs, to remain for long times within the close air of the bivouac without any apparent detriment to health. Furthermore, the large size of the main tracheal vessels of the abdomen and the extensive ramifications of these vessels among the reproductive and other visceral organs indicates that the queen is well equipped in this respect to meet the crucial demands of a greatly increased metabolism during her brief gestational periods.

Although nothing is known concerning the Eciton queen's normal span of life with her colony, in all probability it is equal at least to one rainy season. However, the hamatum queen for some reason is particularly short-lived after removal from the midst of her colony. Three of our 13 contracted specimens lived only two days and only one lived longer than seven days in captivity after capture (see Table I). As a control, one queen (1938 B) was permitted to remain with her colony for more than two weeks in the laboratory, then was removed (without anæsthesis) in good condition, yet this queen died within four days after she was segregated with a small group of workers. Removal from the colony thus seems to introduce some change which makes inevitable the early death of captive Eciton queens. Although in this study various preliminary attempts were made to discover the nature of the lethal factor, the results were not sufficiently clear to warrant discussion here.[8] Whatever this factor may be,

[8] A possibility worth testing is that the Eciton queen when isolated from the mass of her colony is deprived of some essential food substance. For instance, Zahl (1939) has found that workers and queens of the tropical ponerine ant *Dinoponera grandis* sicken and die after a few weeks in captivity unless a larval brood is present in the colony.

it appears to be specific for queens and not for workers, since in all cases workers remained alive in captivity for weeks after their queens had died.

From the above description of workers' responses to the queen during the bivouac-change movement, it is apparent that she must exert a powerfully attractive stimulative effect upon them. The basis appears to be mainly chemical. Even to the human observer the queen is distinguished by a delicate, fragrant odor, quite unlike the heavy, somewhat fœtid odor characteristic of Eciton workers. Workers are especially attracted to pieces of cardboard formerly in use as floors for the queen's cell, and will collect in the one of two compartments in which a queen has rested for a time. In artificial nests they gather about her, and follow closely as she runs about. When she comes to rest they pile the brood around her, and spend much time licking her and stroking her with antennæ. Our queens, placed in small wire cells at the top of the large cylindrical nests in which their respective colonies were clustered, were visited by large numbers of minim workers which penetrated the fine screening and remained to cluster in the cell. Thus the queen may be considered a factor of some importance in normal trophallaxis (Wheeler, 1928), the stimulative interrelationship of individuals which provides the basis for social organization.[9]

Characteristics and behavior of the physogastric queen.—At the time this study began a number of queens of *Eciton s. str.* species had been captured in various parts of Central and South America: notably *E. burchelli* by Wheeler (1921) in British Guiana, *E. vagans* by Gaige in Colombia (Wheeler, 1921), *E. hamatum* by Wheeler (1925), and *E. lucanoides* and *E. mattogros-*

[9] However, it is doubtful that the workers in general are widely sensitive to the actual presence or absence of the queen as Wheeler (1921) implies they were in the case of a colony of *E. burchelli* from which the queen was removed. "I infer," he says, "that this was the only remaining female in the colony, for after her removal a perceptible apathy or dejection seemed to fall on the whole body of ants" (p. 298). Actually, this effect of "apathy," specifically a rather abrupt drop in general activity, characteristically ensues after large numbers of the ants have been stirred up and then permitted to recluster. Once reclustered, they fall into a lethargic condition whether or not the queen has been removed, hence this behavior cannot be attributed to a removal of the queen.

sense by Reichensperger (1926, 1934) and *E. quadriglume* and *E. rogeri* in the Argentine by correspondents of Carlos Bruch (1934). Thus by 1934 the queens of nearly all of the species of *Eciton sensu stricto* had been taken. It is interesting to note that in all of these cases the queen's gaster was contracted, a circumstance which led various writers (*e.g.*, Bruch, 1934) to conclude that the queen in question was "young," or "virgin."

The experience of the present writer was similar in capturing *Eciton s. str.* queens in Panama for behavior studies. In 1933 two queens, *E. hamatum* and *E. burchelli*, were taken; in 1936 four queens, one of *E. lucanoides* and three of *E. hamatum*, and in 1938 nine more of the last species, all of them alike in the fully contracted condition (see Table I). From these and other facts it becomes apparent that few if any of the queens of *Eciton s. str.* reported in the literature could have been virgin when captured,[10] and that the dichthadiigyne must be capable of returning to the contracted state after having delivered eggs. This interpretation in fact was offered as one alternative by Wheeler (1925) in reporting the first capture of the queen of *E. hamatum*.

Early in the present investigation, evidence concerning periodic changes in colony behavior, together with the experience of capturing numerous queens singly from colonies with broods in all stages of development, strongly indicated that the queen must pass repeatedly from the contracted to the physogastric condition, remaining in the latter condition only briefly before returning to the contracted state. Finally it became clear circumstantially that the eggs of a given brood must be laid during a short period of a few days near the end of the first week of the statary phase in colony behavior, when the colony is non-migratory.

Following this conclusion, in 1938 an effort was made to capture a hamatum colony at the critical time, which on circumstantial grounds was placed about seven days after the beginning of the statary period. On July 21 a colony (record number *38 H*) was found which although nomadic at the time was evidently nearing the statary phase, judging from the fact that its larval

[10] Probable exceptions are the two queens of *E. burchelli* taken by Wheeler and Emerson at Kartabo, British Guiana, in 1920 (Wheeler, 1921), in which circumstances point to the recent emergence of at least one and perhaps both of them from cocoons.

brood seemed very advanced and about ready to spin cocoons. After three further bivouac-change movements on successive days, when spinning appeared to be mainly finished in the brood, the colony settled down at a spot near station 4, Barbour trail.[11]

The statary bivouac was formed in a deep cranny near one end of a decayed fallen tree-trunk. The cluster formed a long elliptical curtain-mass filling the opening of the niche. On each of the following days, when the colony was revisited, the ants had only one raiding-system, a typical sign of the statary condition. The site was revisited on July 30, *i.e.*, one week after the beginning of the statary period, with materials for capturing the colony.

The colony had withdrawn about 30 cm. farther into the recess, very probably in response to frequent spattering by rain. Fortunately it was still fairly accessible. The bivouac was quiet, its forward wall sprinkled with ants holding cocoons in their mandibles. A dampened sheet was fastened securely across the opening to entrap the ants, then was sprinkled with ether. After four minutes, when the covering was removed, the major portion of the colony, a mingled heap of ants and cocoons on the floor of the cavity, was quickly scooped into a large jar. A few strands of ants still hanging, together with masses of eggs and clusters of small workers from the rear of the bivouac, were put into a second jar. In examining the material promptly after returning to the laboratory the first jar was found to contain the major part of the large enclosed pupal brood as well as most of the worker population. In the second jar, which contained workers and egg masses from the rear strands of the bivouac, a *physogastric queen* (Fig. 1) presently was brought to light in the part of the mass where workers minor and eggs were most numerous. Judging by relative positions in the jar, this queen must have occupied a position near the back of the cluster, probably among the hanging strands which contained most of the workers minor and most of the eggs. A careful inspection of the material revealed no other queens, no males, and two broods—a large enclosed pupal brood and an enormous clutch of recently delivered eggs.

Within the following twenty-four hours, which proved to be the

[11] The queen was seen in the procession during the final bivouac-change movement, and was judged to be in the contracted condition at that time.

span of life remaining to the *38 H* dichthadiigyne, her behavior was studied as continuously as other duties permitted.—

A few minutes after she was removed from the jar (4: 30 P.M., one hour after capture) the queen appeared to be recovering from anæsthesis, as indicated by reflex twitchings of tarsi and antennæ, although most of the workers remained immobile. At 4: 45 P.M. she had recovered sufficiently to gain an upright posture and had laid 20 eggs. At 5: 10 P.M. she was running about the Petri dish in which she had been placed, despite the trammeling effects of her huge distended gaster which tilted to one side or the other as she moved. From rough measurements at that time, her gaster was 16.5 mm. in length.

Until 8: 15 P.M. the queen remained undisturbed in a darkened Petri dish, laying more than 300 eggs. Then for an hour she was exposed at intervals to brilliant photoflood light when motion pictures were taken. Despite evident disturbance from the light, marked by shock reactions when light was introduced and by turning from the source, there was a describable regularity about the queen's behavior during this interval. There were successive periods of a few minutes each in which the queen stood in place, observably engaged in egg-laying, with intermittent periods in which she ran about the dish more or less continuously, dragging or carrying numerous workers on her gaster and followed closely by others. At no time was she moved by the workers, although generally a number of them remained close to her whether or not she was in motion.

The following representative notes were taken during two of the quiescent intervals, the first lasting 5 minutes after 9: 37 P.M. and the second 2 minutes after 9: 44 P.M.:

The queen abruptly breaks pace and suddenly stops in place, headed away from the photoflood source. She stands firmly on all six legs, with the ventral surface of the gaster resting on the floor. In oviposition, the eggs emerge in a wide jet from the vaginal orifice, and spread out radially upon the hypogynium. The process is marked by slight laterad oscillations of the the gaster and a shivering of the body and legs, which cease when eggs no longer emerge.—Eggs were laid during both of these halts.

At 11: 30 P.M. the queen with 6 workers was placed in dim light for observation. During the next 90 minutes there were 11 quiescent periods, varying between 30 sec. and 11 min. in duration (6 of them lasting between 1 and 4 min.). The intervening periods of activity were shorter, most of them around 3 min. in duration. In each case, locomotion began rather abruptly. The quiescent periods likewise began abruptly, with the queen usually sprawling close to the floor at once. Generally she stopped in a position facing away from the light, which although dim was sufficient to orient her. In some of the shorter intervals no eggs were laid. In the course of one or two of the longest stops, the queen shifted position briefly or moved forward a short distance once during the interval. The workers remained close to her, frequently applying their mouth parts to her body at the vaginal orifice and

at the surface of the hypogynium and licking these surfaces. After one of the stops a drop of viscous greenish-yellow fluid remained where the tip of the queen's gaster had rested. The workers soon found this drop and applied their mouth parts to it, evidently feeding.—Observations were discontinued at 1: 30 A.M., since no eggs had been laid during the preceding 30 minutes.—Between 5: 10 P.M. and 12: 00 A.M., 1245 eggs were laid.

In the morning, at 6: 30 A.M., only 358 eggs were found to have been laid during the night (*i.e.*, after 1: 30 A.M.). As before, alternating periods of quiescence and of activity were observed. Between 8: 15 and 9: 54 A.M. the queen was shielded by a ruby-glass filter and remained under observation. During this interval there were sixteen quiescent periods alternating with intervals of continuous locomotion, virtually all of the phases of quiescence and of activity falling between 1 and 4 min. in duration. In some of the stops between 20 and 30 eggs were laid, in others no eggs. The following notes typify egg-laying behavior:

8: 23 to 8: 26 A.M.—The queen stops abruptly, facing away from the weak light. Promptly there begins a shivering movement of the gaster, increasing at times to an oscillatory movement; then the oscillation becomes continuous, at times reaching 1 mm. in amplitude. These oscillations of the gaster begin locally and increase in amplitude, meanwhile spreading to include the entire body with the legs participating. Near the height of such spasms the eggs begin to appear. A jet of eggs between 12 and 15 units wide is forced slowly from the vagina directly backward over the hypogynium, with the eggs fanning radially to each side as they emerge. The eggs in small packets are either picked off by the workers or drop to the floor when the queen moves away.—Finally the queen breaks abruptly into motion, in an interval of locomotion which lasts 4 minutes in this case.

At 4: 15 P.M. the queen seemed less energetic than in the morning, and had laid only about 60 eggs since 10: 00 A.M. For about 20 minutes she was exposed to bright sunlight while photographs were taken, and although she was shaded between exposures the intense light appeared to exert a decidedly injurious effect upon her. At length she fell upon one side with flexed legs, unable to regain an upright position. At 6: 00 P.M. there were unmistakable signs of approaching death, which in the contracted queen is characterized by intermittent struggling and by local tarsal and antennal reflexes lasting a number of hours.—At 6: 30 P.M. she was chloroformed for fixation in Carnoy's solution and eventual preservation in 70% alcohol.

Notwithstanding the fact that disturbances incident to laboratory captivity must have disrupted the normal oviposition mechanism greatly, and although the factors which characteristically hasten death in captive Eciton queens must have been at work, certain inferences concerning the normal circumstances of physogastric function may be drawn from these observations. Concerning the queen herself, the regular occurrence of short

intervals of action and of quiescence (and egg-laying) in alternation indicates that a rhythmic process underlies the delivery of eggs from the ovarioles. The abrupt onset of each quiescent period together with the oscillatory movements of the gaster and at times the entire body during oviposition speak for the operation of a fairly distinct egg-laying process arising at short intervals. Likewise, the abruptness with which the queen broke into motion after each quiescent period indicates the regular recurrence of a rhythmic change in this process, evidently a phase during which more eggs became viscerally available for delivery.

Under the conditions of these observations the queen was attended by only a few workers, and space permitted her to run about in the intervals between egg-laying stops. It is probable that under normal conditions in the bivouac, when she is surrounded by masses of workers, free locomotion is out of the question for the queen. In that situation her viscerally-stimulated overt activity must be reduced to stirring in place and to interstimulative relations with workers.

This queen died with a considerable portion of her eggs still undelivered, a fact which together with other circumstances indicates that in all probability lethal processes setting in with captivity impaired the egg-production rhythm seriously from the beginning. Under normal conditions in the bivouac this rhythm presumably functions smoothly and continuously throughout the period of approximately four days in which all of a given clutch of eggs is delivered. Then, as we shall see, circumstances are such that the queen, contracted once more but in an exhausted condition, may profit by a long interval of recuperation before the parturitive ordeal must be repeated.

Our results shed some light upon the behavioral relation of the physogastric queen to her colony. First of all, the fact that the queen is quite capable of locomotion during her time of physogastry effectively negates the hypothesis (Müller, 1886) that the colony must remain in place at such times because of an inability to drag along the heavy egg-laden queen. She moves readily, and even drags or carries workers about with her, hence there is reason to believe that she would be quite capable of joining a bivouac-change movement if one happened to get under way. She would

have to make periodic (viscerally enforced) stops on the trail, but could make the trek even though it might well be fatal. We shall find that the sessile (*i.e.*, statary) status of the colony when the queen is laying her eggs is indeed related to the queen's oviposition cycle, but very indirectly, and very differently than the above hypothesis would suggest.

Our observations indicate that the normal stimulative attractiveness of the queen for the workers (*i.e.*, her trophallactic relationship with workers) is considerably increased during the time of oviposition. The intersegmental membranes of her enormously swollen gaster and the hypogynium and vaginal regions in particular are highly effective centers of attraction. The workers are constantly crawling upon her and licking these regions as well as the eggs when they appear (*cf.* Wheeler, 1900) and the (evidently much relished) small drops of fecal material which issue at times after egg-depositing episodes.[12]

There can be little question that this queen produced all of the eggs taken with the colony, a total of 17,062, which was estimated to be two or three thousand short of the actual number laid prior to capture. To this we may add 2,046 eggs laid while the queen was held captive, and 7,190 unlaid eggs taken from her gaster in post-mortem study. The total of 26,298 eggs approaches fairly close to the size of Eciton brood populations for which census studies have been made in other cases, offering further evidence that one individual dichthadiigyne is capable of delivering single broods of that size. In view of circumstances indicating that the eggs of each huge brood are laid within a short interval of probably no more than three or four days, the entire performance seems quite worthy of being termed a stupendous feat.

The great susceptibility to death of the Eciton queen in this condition is attested by the fact that our specimen survived only about 30 hours after capture. It is probable of course that her demise was hastened by the anæsthesis and by other shock-effects (*e.g.*, from intense light during photography), yet the fact that *contracted* queens similarly treated usually remain alive for as long as a week in captivity speaks for a specific physiological vulnerability to non-optimal conditions in the *gravid* Eciton

[12] Emerson (1939) has reported a similar observation for queen-worker relationships during egg-laying in termites.

queen. It is a fact of great adaptive significance that during this biologically critical time the dichthadiigyne ordinarily is assured the essential optimal situation through the operation of intrinsic factors which render the colony sessile. No less remarkable is the fact that *the queen herself, through her peculiar reproductive properties, is indirectly the basic controller of this state of affairs.*

EVIDENCE FOR A FUNCTIONAL RELATIONSHIP BETWEEN BROOD AND COLONY

Significant periodic differences in colony behavior.—As the first step toward working out relationships between the queen and her colony, let us examine the general situation of the series of *E. hamatum* colonies from which queens were captured for this study (see Table I).

In their behavior twelve of the hamatum colonies (*i.e.*, colonies *33 A; 36 A, B, D,* and *G;* and *38 C, X, D, E, F, G,* and *I*) from which queens were taken conform to the pattern previously described as "nomadic" (Schneirla, 1938). On the other hand only three (*i.e.*, colonies *38 A, B,* and *H*) conform to the pattern described as "statary." Since all of these colonies were studied for at least three days prior to capture, and some of them for longer times, any important deviations should have become apparent; but in all cases there appeared very clearly the characteristics of one or the other of the described activity patterns.

In cases showing the *nomadic* pattern, all of the colonies were *migratory,* that is, they had all engaged in bivouac-change movements near the end of each day in the period preceding capture. Without exception among many observations, the raiding activities of a given day *were terminated* by a complete movement of the colony, generally during the evening and early night, so that the next day found the colony developing a new raid from a different site generally more than 100 meters removed from the last.

Although their bivouacs were situated in rather different topographical circumstances, the clusters of the "nomadic" colonies were not secluded as is typical of statary colonies. The former almost without exception established themselves beneath logs, under matted vines, or against the sides of trees between buttressed roots, seldom within cavities such as hollow logs or trees. As a rule the larger portion of the more or less cylindrical mass

DATA RELEVANT TO THE 15 QUEENS OF *E. hamatum* CAPTURED IN THE PRESENT STUDY, AND TO THE COLONIES FROM WHICH THESE QUEENS WERE TAKEN (*cf.* FIG. 2)

Colony	Date (when queen captured; brood sampled)	Condition of queen, and span of life in captivity	Brood or broods: Eggs*	Brood or broods: Larvæ*	Brood or broods: Pupæ	Colony behavior
1933A	6/16/33	Contracted		Early stage		Nomadic
1936A	9/14/36	Contracted (6 da.)		Early stage	(Callows)	Newly nomadic
B	8/ 8/36	Contracted (3 da.)		Early	(Callows)	Newly nomadic
D	9/ 8/36	Contracted (4 da.)		Nearly mature		Nomadic
G	9/12/36	Contracted (7 da.)		Advanced		Nomadic
1938A	6/11/38	Contracted (7 da.)		$R = 0.36–0.73$ mm. $M = 0.46$ mm.	Advanced	*Statary*
B	6/15/38	Contracted (3 da.)		$R = 0.40–0.66$ mm. $M = 0.51$ mm.	Advanced	*Statary*
C	6/19/38	Contracted (3 da.)		$R = 0.35–2.0$ mm. $M = 0.75$ mm.		Newly nomadic
D	6/22/38	Contracted (10 da.)		$R = 0.44–3.68$ mm. $M = 1.23$ mm.		Nomadic
E	6/28/38	Contracted (7 da.)		$R = 0.35–4.20$ mm. $M = 1.8$ mm.		Nomadic
F	6/30/38	Contracted (4 da.)		$R = 0.60–4.35$ mm. $M = 1.76$ mm.		Nomadic
G	7/12/38	Contracted (6 da.)		$R = 2.10–6.58$ mm. $M = 3.32$ mm.		Nomadic
X	6/28/38	Contracted (2 da.)		$R = 0.36–0.73$ mm. $M = 0.47$ mm.	Callows	Nomadic
H	7/30/38	*Physogastric* (30 hr.)	$R = 0.26–0.58$ mm. $M = 0.47$ mm.		Early pupal	*Statary*
J	8/ 8/38	Contracted (returned to colony after 12 hr.)		Very young larvæ		Nomadic

* The growth stage of the respective broods taken in 1938 is represented by data on the range (R) and the mean (M) of body lengths (samples ranged between 25 and 200 specimens from each colony). The writer wishes to express his thanks to Miss Ruth Greene, who generously contributed her time to gather these data.

The larvæ of various *Eciton* species have been described by G. C. Wheeler (1943) with a key for their identification.

of ants was fairly exposed to view. It is typical that the bivouacs of nomadic colonies are far more readily approached and observed than are those of statary colonies.

In their raiding, particularly, colonies in the two behavior conditions exhibited very different characteristics. In the nomadic condition the Ecitons always staged vigorous daily raids which began promptly with the first daylight and grew rapidly into the characteristic maximal raiding pattern of the species. In *E. hamatum* this is marked by the growth of two or three (generally three) principal raiding systems, each a tree-like pattern of trails with a single principal trail as its line of communication with the bivouac. Although of course the details of the trail systems vary considerably according to the situation of the bivouac and the general topography, invariably multiple trail-systems are found under nomadic conditions. At such times a maximal number of ants from the population is drawn into the daily foray, developing extensive and complexly branched trails on a widespread front of raiding. With the raid probing out along a number of principal lines, the usual result is that roughly three-fourths of the circular zone around the bivouac is invaded, with the consequence that relatively enormous quantities of booty (mainly the soft-bodied young of other insects) are gathered in. *While nomadic, a colony remains near its peak of vigor in raiding and in other activities.*

With those colonies in the statary condition when their queens were captured the case was quite different in all important respects concerning behavior. Colonies *38 A, B,* and *H* were all known to have remained in their same bivouacs at least three days prior to capture. Colony *H,* for example, after three observed daily bivouac-changes, clustered within a large crevice in the side of a massive log on July 22, 1938, and was found in the same place and in almost the same spot on July 30, when captured.

Other evidence has been offered (Schneirla, 1933, 1940) for the existence of the statary period as a distinctive "sessile" phase of Eciton life. Observations on particular colonies extending over considerable periods have shown that once a hamatum colony enters a statary phase, it remains bivouaeked in the same place

and exhibits other characteristic "statary" features of behavior during a period of approximately 19 days, before a major change occurs.

The fact will be recalled that of the fourteen colonies from which queens were captured in this study, only three were taken in the statary condition. This difference is scarcely a matter of accident, but is due to the relatively secluded locations taken by colonies of *Eciton s. str.* when they are statary. Colony *38 H*, clustered in a deep crevice on the outer wall of a huge log, was unusually accessible for a statary colony. The virtual impregnability of statary colonies is attributable to two facts in particular. First, they are commonly clustered within a cavity, generally in a hollow log or tree. Colony *38 A* had to be extracted from a hollow log, colony *38 B* from within the large hollow root of a standing tree, by drilling a circle of holes with brace and bit and breaking out an opening through which the ants could be removed by hand.[13] Then, too, if a statary colony happens to settle where it is somewhat exposed to the elements, disturbance from wind, rain or sunlight causes the ants to shift their position so that after a few days capturing them would require the assistance of a wrecking crew. The proneness of colonies to cluster in hollow logs or trees when entering the statary period stands as a highly adaptive circumstance for which no specific explanation can be advanced at the present time.

Without exception, each of our three statary colonies from which queens were obtained had a single raiding system when captured. This pattern is readily recognized by the presence of just one principal raiding trail leading from the bivouac, rather than two or three as in the nomadic phase. Distance reached from the bivouac in the raiding is not a secure criterion of its relative vigor, since in the statary phase the chemically-marked route of a previously used trail may be employed on more than one day so that such trails often become greatly extended beyond the distances ordinarily reached in nomadic-phase raiding. As more certain indications of reduced raiding, the number of principal systems is one rather than three, and there is a smaller

[13] Dr. Neal Weber kindly assisted in this operation, which was completed in a torrential rain.

number of branch trails in that system than is characteristic of a raiding system in the nomadic phase. Thus, *in the statary phase, raiding activity falls much below the level of vigor and of numbers involved during the nomadic phase.*

Before considering the relationship of these periodic differences in Eciton behavior, it is desirable to examine correlated differences in the internal constitution of the colony.

Intrinsic conditions underlying colony behavior.—A consideration of the internal characteristics of the colonies (see Table I) shows that the external behavior differences were paralleled by others no less outstanding. The intrinsic differences may be represented by a comparison of the two groups of colonies in terms of their condition and the status of their brood or broods when the queens were captured.

First of all, it should be emphasized that the broods invariably were *worker broods,* and that no batch of larvæ or pupæ contained individuals departing sufficiently from the others in form or size to suggest the anlagen of fertile forms. This statement is of course not based upon our present facts alone, but finds its main support in an examination of hundreds of Eciton broods on Barro Colorado Island in *rainy months* between May 15 and September 20 in four different years which has disclosed none but worker forms in them.

Another fact of significance is that while each of the broods contained tens of thousands of individuals, all members of a given brood were *roughly at the same stage of development.* This condition held not only when a single brood in the larval stage was present, but also for cases in which there were two broods (*i.e.*, a pupal brood in addition to a brood in the very early larval condition). This statement, likewise, is based not only upon the present data but also upon the invariable finding that in *E. hamatum* the entire population of a given mature larval brood terminates that stage and spins cocoons within a very few days, and that pupal broods mature and are removed from their cocoons as callows within a similarly short period of three or four days.

All three of our statary colonies had two broods at well-separated points of development, a fact which we shall find characteristic of the *latter* part of this activity phase. Colony *38 H* con-

tained a well-advanced pupal brood as well as a massive batch of newly laid eggs. Colony *38 A* contained a still more advanced pupal brood, and its younger brood had largely hatched and passed into the early larval period. The two broods of colony *38 B* corresponded in general to those of *38 A*. In the early days of the statary period only one brood (always a pupal brood) is present.

In contrast, the nomadic colonies each contained only a single brood, in every case *in the larval condition.* From the size data on these broods, represented in Table I by the averages and ranges of individual body lengths, it is apparent that the broods were at very different stages of development when the colonies were captured. If a greater magnitude of body length in the brood (as indicated by larger averages and greater ranges) may be taken as valid evidence for an advanced point in growth, the nomadic colonies captured in 1938 may be placed in the following sequence: *X*, *C*, *D*, *E*, *F* and *G*. It will be noticed that with the single exception of colony *X*, there is a correspondence between the chronological order of capture and the growth point attained by the respective broods. The possible significance of this fact will be considered in a later connection.

When we bring together our facts concerning the external and internal characteristics of the colony, a significant parallelism is evident between them for both the nomadic and the statary phases. In the statary phase 1) the colony does not migrate but remains in a given place, 2) by virtue of its secluded location it is well protected from the elements and from animals, 3) it raids minimally and is comparatively lethargic, and 4) it contains a pupal brood and in its latter part (*e.g.*, colonies *38 A*, *B*, and *H*) eggs or a young larval brood as well. *The most significant parallel circumstances are a low condition of colony activity and a brood (or broods) incapable of overt activity.*

In sharp contrast to the above situation, a colony in the nomadic phase 1) regularly moves to a new bivouacking site at the end of each raiding day, 2) generally bivouacs in fairly open places, 3) raids maximally and appears to be always (*i.e.*, in the daytime) near the peak of activity, and 4) contains a single brood in a more or less advanced larval phase. In this case, *the*

most significant parallel circumstances are a high point in colony activity and the presence of a larval brood which is capable of overt activity.

Theoretical explanation of the parallelism between brood condition and colony behavior.—These facts suggest that a causal

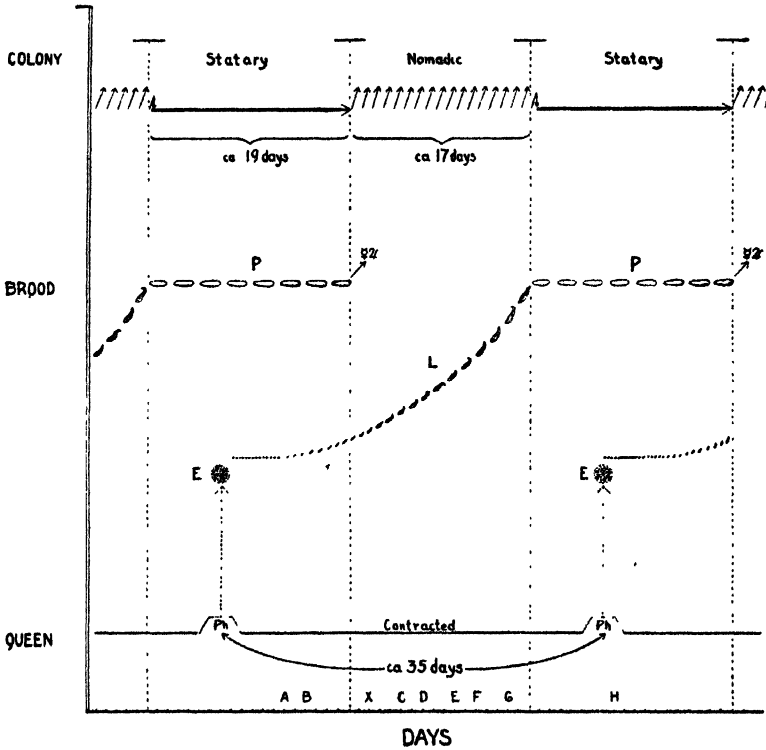

FIG. 2. Schema to represent concurrent events in *colony behavior* (top), *condition of the brood*, and *function of the queen* in *E. hamatum.* (The sequence of given events in the colony may be traced horizontally, the concurrence of events, vertically.) *A–H*, approximate situation of the respective colonies from which queens were captured in 1938; *Ph*, physogastric interval of the queen; *E*, egg mass delivered in given physogastric interval; *L*, larval stage of brood; *P*, pupal stage of brood; ☿ ♃, workers minor and major of a callow brood.

relationship exists between the condition of the brood and the circumstances of general activity in the colony. The conclusion appears justified that conditions arising from the capacity of the

brood for overt activity somehow account for the critical difference which appears in general colony activity pattern when active broods rather than "passive" broods are present. This idea has been advanced in a previous connection (Schneirla, 1938) and will be carried further presently.

Evidence from field observation and special test supports this inference of a causal relationship dependent upon condition of the brood. Batches of eggs and very young larval broods (as in the statary colonies *38 A, B,* and *H*) are as a rule gathered into a single mass or a few masses which are covered and at times permeated by minim workers and are only very indirectly in contact with the adult population of the colony. On the other hand, when the larvæ have developed further (as in colonies *38 C, D, E, F, G,* and *X*) and their twisting movements become perceptible to the unaided eye, these masses are broken up and more or less distributed through the bivouac, so that larval activity and other stimulative effects may directly reach large numbers of adult workers. When the larvæ mature, and become enclosed in cocoons, it is apparent that in the ensuing pupal stage (as in colonies *38 A, B,* and *H*) they become passive contents of the bivouac. Heaped in interior pockets of the cluster and held by workers distributed through its wall, they are presumably neutral in importance or may actually exert a quieting effect upon the workers that clutch them in their mandibles, somewhat as the pressure of thumb-in-mouth pacifies an infant.

From laboratory observations we may say that through the presence of an active larval brood the workers are distinctly stimulated so that the amount and the vigor of their activity increases greatly. When Ecitons are divided into part-colonies of comparable size, it is the groups with larvæ that show the greater activity both within the confines of their artificial nest and in the frequency of visits to an adjoining food-place, as compared with groups that have no brood or have a pupal brood in cocoons. When we study the relationships of individuals within the nest, there are clear indications that this difference in activity level actually depends upon a stimulative effect from the larval brood. Typically the larval brood is spread over an area, usually around the queen if one is present. The workers move restlessly around,

frequently touching the larvæ with mouth-parts or licking them, intermittently touching and stroking them with antennæ, often picking them up and shifting their position slightly or carrying them bodily from place to place. When pieces of food are carried into the innermost nest area, they are commonly deposited near the larvæ or actually laid upon them, so that in their almost incessant twisting movements the larvæ readily bring their mouth parts into contact with the food.[14] It is a common observation that stimulation from passing workers may arouse quiescent larvæ to squirming activity, or that chance stimulation from larvæ may bestir workers. It is manifest that the larvæ thus in a number of ways arouse the adults to increased activity, in the mutual stimulative relationship between adults and brood which Wheeler (1928) has termed "trophallaxis."[15]

On the other hand a group without any brood or with pupæ in cocoons is distinctly less lively than when larvæ are present. Even when exposed to light the workers seldom appear very excited, and most of the time they stand quietly over their heap of cocoons or near it, or move slowly about in the vicinity. Under these conditions Ecitons are chronically less feverish in their activity, indulge in many fewer excursions from the nest, and hence they carry in far less food than in the larva-containing situation. We may say that *the group or colony which contains active larvæ as in the nomadic period has a special source of colony "drive."* In contrast, in the statary period, this factor is greatly reduced when interindividual stimulation is limited to relationships among adult workers themselves.[16]

[14] Gallardo (1920) has commented upon the great mobility of Eciton larvæ.

[15] The gastric anatomy of the larvæ of *E. burchelli* and the feeding behavior of these larvæ have been described by Wheeler and Bailey (1920). In this species the larva is fed at frequent intervals on boluses composed of the soft parts of insect prey, laid by the workers upon the ventrum of the larva or actually thrust into the larval gullet.

[16] From his observations on a colony of *E. burchelli*, Wm. Müller (1886) inferred that an increase or decrease in the raiding activities of a colony is attributable to the relative need of the brood for food.

> "Larven brauchen ja im allgemeinen, besonders kurze Zeit vor der Verpuppung, bedeutend mehr Nahrung als die fertigen Insekten, und so scheint nichts natürlicher, als dass das Nahrungsbedürfnis der

However, in a statary colony with advanced pupæ there is a marked change in the general level of activity when the nearly mature individuals begin to move within their cocoons. When a close approach to the end-point of pupal development is indicated by the appearance of a distinct pigmentation of eyes, mandibles, and anterior sections of the body, activities such as twitchings of the legs and slight turnings of the body become observable. Such movements of the pupæ may be increased by picking individuals up with tweezers or by lightly probing the body, just as they are perceptibly elicited when the cocoons are picked up by workers. The stirring of mature pupæ appears to excite the workers and evidently leads to the removal of the brood from cocoons; the envelopes readily tearing open as the workers manhandle them (Schneirla, 1934, pp. 320–321). That the opening of cocoons depends critically upon pupal movements is suggested by the fact that test groups did not open cocoons in which the advanced pupæ had been killed with a needle (*op. cit.*, 1938, p. 66).

There is a distinct increase of excitement in an Eciton colony as emergence of its brood gets under way. The excitement rises in crescendo until, a day or two later when the largest part of the brood is free and active as callow individuals, the colony shakes itself from the statary period by staging an exceptionally vigorous raid *ending in a bivouac-change movement.* Laboratory observations show that in the appearance of a new pupal brood and in the strong stimulative effects from callows during their first few days as "free" individuals in the colony, an Eciton worker population receives a great lift in internal "drive." The conclusion seems in order that this internal change is responsible for setting a colony into the nomadic phase.

Gesellschaft ein geringeres wird und die Tiere entsprechend weniger auf Beute ausgehen, nachdem alle Larven eingesponnen" (p. 87).

While this point undoubtedly has relevance to the *phylogenetic* problem (concerning the evolution of the Eciton behavior pattern) and describes an important adaptive function of the pattern, it is teleological and misleading if applied to the *ontogenetic* problem (concerning the contemporary causation of the pattern in a given colony). As the present discussion shows, it is not the brood's food-consuming capacity as such, but the presence or absence of incidental tactuo-chemical stimulation from the brood which critically governs periodic changes in colony behavior.

Our theory thus accounts for the nomadic-statary (rainy-season) cycle of Eciton colony activity in terms of cyclical changes in the internal stimulative properties of different broods. In Figure 2 the relationship is represented schematically in terms of a diphasic diagram, on which are indicated the positions evidently attained by our colonies at the times their respective queens and broods were captured. The "trough" phase of the cycle signifies the statary period, in which the colony is held in position and is comparatively inactive and the brood or broods relatively passive in their social rôles. A colony enters this statary phase when the enclosure of its mature larval brood removes the major internal source of special social stimulation. The appearance of a new brood as eggs laid after about one-third of the period has elapsed does not materially change general colony behavior, since with this brood concentrated in masses, incapable of movement, it can exert only a relatively negligible stimulative effect upon the general population. As a matter of fact, the vigor of raiding seems to decrease somewhat toward the middle of the statary period, and hamatum colonies sometimes show raidless days then (also *E. burchelli*, as Müller (1886) noticed). With social stimulation low throughout the period, the workers are only weakly stimulated to leave the colony in raiding, with the result that statary-period raids are relatively feeble as compared with nomadic-period raids.

We may say that in the statary period a low summation of colony excitement directly expresses its limitations in the underdevelopment of raiding, which roughly is only about one-third as extensive as in the nomadic period. Such raids may be regarded as underdeveloped not only in their restricted numbers and scope but also in falling below the threshold of development at which a bivouac-change movement becomes inevitable.

To speak of a "threshold" of raiding essential for new behavior requires us to show why underdeveloped raids cannot lead into a colony movement. This has been done in special studies of the relationship between raiding and the bivouac-change movement (Schneirla, 1938, 1944) which bring out the reason why a colony can withdraw to its original bivouac from an underdeveloped statary-period raid but must move onward when a maximal

nomadic-period raid has been staged. The actual behavior process, fairly complex, centers around the fact that in the statary period the colony is insufficiently rearoused (by regular post-meridional atmospheric changes) after the midday lull in activity, so that no exodus exists capable of blocking the principal trail to returning raiders. In the nomadic period, on the other hand, the afternoon rearousal produces a lasting afternoon exodus from the bivouac which forcibly reorients returning raiders outward in at least one trail system; then a movement from the bivouac persists on this route, eventually draining the entire colony to a new bivouacking site. Thus when extrinsic stimulation (from light in particular) drops away at dusk, a colony in the statary phase loses its principal source of arousal and gradually approaches quiescence; whereas a colony in the nomadic phase when raiding declines with dusk possesses an adequate and persistent internal "drive" facilitating the vigorous exodus already in progress. The key to the situation appears to be the radical difference in the intrinsic properties of colonies in these two conditions.

The break from the statary phase appears to be accomplished not through the influence of the new larval brood, which at that time seems insufficiently developed to be a social-stimulative factor of any account, but rather through activities centering around the maturation of the pupal brood and its appearance as an enormous horde of hyperactive, voracious callows. Invariably, hamatum colonies shift from their statary sites when the pupal brood has largely emerged; the deserted spot is littered with empty cocoons, and the first bivouac-change processions are distinguished by crowds of pale-colored callow workers. Circumstances indicate that the stimulative effect from tens of thousands of callows not only serves to bring the colony into nomadic life, but also persists for a few (apparently about five) days as a factor of similar influence and importance. Our colony *38 X* was taken at such a time. As a major source of stimulation, the presence of the callows appears to overlap the involvement of the new brood of larvæ, in that as the callows lose their early social-stimulative effect and merge into the adult worker population, the larvæ become increasingly functional in this respect. About five

days after the nomadic period has begun, typically, the callows are almost indistinguishable from regular workers and (judging from laboratory observations) have dropped to the level of the ordinary workers in their trophallactic properties. Meanwhile, the larvæ have increased notably in size and activity, most of them are capable of feeding, and at this time they appear to constitute the new major source of social stimulation or intrinsic colony "drive." Our colony *38 C* was taken at such a time. When it was captured, the larval brood was distributed rather widely through the interior of the bivouac, and in the laboratory a pronounced activity was noted in all but the smallest size category.

Colonies *38 C, D, E, F,* and *G* (taken in chronological sequence) may be placed at successive points in the nomadic period on the basis of the invariable fact that an increasing development of the larval brood parallels an advance through this phase of activity (see Fig. 2). Not only are the trophallactic properties of the brood instrumental in maintaining the nomadic pattern of behavior by supporting daily maximal raids, but as the larvæ develop further their influence appears to increase. The apparent augmentation of their social effect probably is due to increased chemo-stimulative properties as well as to greater general activity as they grow. This is suggested by laboratory observations and by the fact that in the bivouac more advanced broods tend to be widely distributed through the cluster, single larvæ held by individual workers much more frequently than with younger broods. Thus the intrinsic "drive" effect of the brood not only maintains the nomadic pattern in the colony, so that maximal raids and bivouac-change movements appear regularly in the daily routine, but this relationship appears to rise through a crescendo as brood development nears its climax. Hence, near the end of the nomadic period, raids are more extensive and more heavily populated, and colony movements tend to carry over longer distances than earlier in the period. In particular, this is revealed by studies of individual colonies throughout the nomadic period (*e.g.,* colony *1936 A,*—Schneirla, 1938; also *E. burchelli,* colony *38 I,*—Schneirla, 1944).

As we have pointed out, in addition to postulating an excitation to "maximal' raiding through the drive effect of active broods,

the theory postulates a given threshold in raiding which is essential for the occurrence of a bivouac-change. As the relationship has been worked out in a previous paper (*op. cit.*, 1938), only in the nomadic period does raiding attain the pattern (*i.e.*, three trail systems in *hamatum*) and the degree of colony involvement that is required if it is to eventuate in a colony movement. That the essential "maximal" pattern of activity in the colony depends specifically upon a characteristic larval-brood influence is suggested strikingly by the regularity with which colonies lapse into the statary period on the very day most of the larvæ have spun their cocoons.

It seems clear that since a critical difference in the pattern of hamatum colony behavior depends upon the condition of the brood, the ultimate determination of such matters resides in the individual that produces the broods, *i.e.*, the queen.

THE ECITON QUEEN AS PACEMAKER FOR COLONY BEHAVIOR

It is characteristic of *E. hamatum, E. burchelli,* and other representatively terrestrial species of *Eciton s. str.* (if not Ecitons generally), that broods appearing in the rainy season are very large, and that all individuals in a given brood develop concurrently. That is, in each new *hamatum* brood the eggs are laid within a span of a few days, pass through the larval period essentially in step, enter the pupal stage within about four days, and appear as callow workers all within a very short period. Obviously this state of affairs depends essentially upon the reproductive properties of the Eciton queen.

Let us first consider some further facts about brood development that throw light indirectly upon the capacities of the queen. Population studies have been made with four broods captured on Barro Colorado Island, with these results: *E. hamatum*—a larval brood, 26,452 individuals (not complete), a pupal brood, 31,379 individuals (fairly complete); *E. burchelli*—one complete larval brood of 36,888 individuals, and a pupal brood of 31,298 individuals. Then too, the mass of eggs from physogastric queen *38 H* totalled more than 26,000, probably with a few thousand missing. Since many other broods inspected in the egg, larval, or pupal condition were comparable in bulk with these populations

which were actually counted and sized, it seems that the rainy-season broods of *E. hamatum* (and of *Eciton s. str.* broadly) are typically very large. In all probability the broods in this season comprise more than 25,000 individuals as a rule. That a single queen is capable of delivering an egg mass of these proportions within a few days is an impressive fact.

Beyond the fact that in nearly twenty captures we have never found more than one queen in a colony, and the fact that the enormous clutch of eggs in colony *38 H* may be attributed safely to a single queen, our evidence on condition of the broods seems to exclude any possibility that more than one queen figures in producing a given brood. First of all, the range and central tendency of body size in young and advanced larval broods are rather constant for given stages (see Table I). The range of individual sizes is at first limited (*e.g.*, colonies *38 H, A, B,* and *X*) but increases with the general age of the brood (colonies *38 C, D, E, F, G,* and others). That there is a definite unimodality in the distribution of individual sizes within a given brood was indicated by study of the broods mentioned above, and has been verified in all four of the broods surveyed in toto. Furthermore, all brood distributions are skewed toward the worker-minor extreme. With the population classified into five body-size categories (in terms of body length), with No. 1 the smallest and No. 5 the largest, the mode falls in category No. 2 as a rule, well below the median value. For example, in a hamatum pupal brood (of 31,379 individuals in cocoons) which was surveyed, the following distribution was found through the five size categories, from smallest (ca. 5 mm. long) to largest (ca. 10.5 mm. long): 5,209, 16,860, 8,072, 870, and 368, respectively. The prevalence of the described distribution pattern in Eciton brood populations indicates the involvement of a single reproductive source in each case, a maternal source having definite and regular properties.

As further evidence we may repeat the fact that enclosure of the larval brood and the opening of cocoons when a pupal brood hatches are matters of mass change, both events accompanied by prominent changes in colony behavior. In view of these considerations together with our invariable discovery of but one queen to a colony in many captures, the conclusion seems justified

that these large worker broods appearing in *hamatum* (and in *burchelli*) colonies are attributable to single queens in the respective cases.[17]

Furthermore, the time relations of successive broods in given colonies are sufficiently predictable to suggest the function of but one queen in each case. The results from colony *36 A* (*E. hamatum*), which was studied during a period of 42 days, from August 5 to September 15, 1936, bear directly on this point (Schneirla, 1938). During seven weeks of observation, this colony passed from a statary period into a nomadic period which lasted 17 days, then spent 19 days in a new statary period, after which it entered a further nomadic period. Three successive broods were observed, all of them relatively immense and entirely composed of worker forms. The first of these broods terminated its development and appeared as callow workers when the study began. The second brood was present as developing larvæ through the complete nomadic period, was enclosed in cocoons and entered the phase of pupation when the fully observed statary period began, passed through its pupal development and appeared as callows as a further nomadic period got under way. The eggs of the third brood were laid at some time between August 28 and September 6, and this brood was well started on its larval development when the colony was captured September 15. In the end the colony was anæsthetized and thoroughly examined. Only one queen (in the contracted condition) was found.

This evidence is brought together in the schematic representation of the hamatum behavior cycle in Figure 2. The condition of the brood or broods as indicated at times of major change in colony behavior corresponds to the facts for colony *36 A* and checks with many other cases, as does the representation of a developing larval brood through the nomadic period and a pupal brood through the statary period. Our records indicate that in the area of this study individual hamatum (and burchelli) colonies characteristically pass through the cycle of correlated behavior changes and worker-brood production a number of times

[17] A possible alternative explanation is that the broods are the product of two or more queens with exactly synchronized visceral rhythms. This seems very doubtful, especially because no polygynous colonies have been discovered.

in regular succession during the first four or five months of the rainy season.

To describe the characteristic time relations of the principal changes in brood development for *hamatum*, it is necessary to ascertain the time at which the eggs are laid more exactly than is possible from the record of colony *36 A*. From general evidence, and from the facts concerning queen *38 H*, we have inferred that the process of egg-laying occurs during a short period following about one week after the beginning of the statary period. The conclusion that normally a new brood appears as eggs about ten days before the end of each given statary period is supported directly and indirectly by numerous facts. In particular, although eggs are never found in colonies examined during the first few days of the statary period, large masses of eggs are found during the last week of this period. Queen *38 H* evidently had just passed the peak of an egg-laying process when captured seven days after the beginning of a statary period. Since in *hamatum* oviposition appears to be of short duration, probably no more than three or four days from beginning to end, if we set 18–20 days as the usual length of the statary period in this species we may say that the new brood has roughly ten days of early development before the statary period ends.

On this basis we may estimate the developmental period of a given brood. To the first 10 days of embryonic and early larval growth when the colony is statary, and 17 days to complete larval development in the nomadic period, we may add 19 days (as a close approximation) in the pupal stage during the following statary period. That makes a total of 46 days for the complete development of a hamatum brood. Other facts plainly indicate that the interval between the appearance of successive broods in a given colony is the number of days from the end of one statary period (when one brood is delivered as callows) to the end of the next statary period (when the next brood is delivered), *i.e.*, about 35 days.[18]

[18] As may be seen in Figure 2, the difference of about 10 days in the above figures is attributable to the fact that the oviposition and early development of a given new brood overlaps the period in which the preceding brood is completing its pupal maturation.

On this basis we may arrive at an approximation of the interval between successive occurrences of the short but strenuous oviposition act of the queen. After having deposited a given clutch of eggs, the queen evidently lays no more until the early part of the next statary period. If the peak of one process is roughly placed at seven days after the beginning of a statary period and its end at nine days, for the ensuing resting phase there are ten days remaining in the same period, 17 days in the ensuing nomadic period, and perhaps five days in the following statary period,—32 days in all for the interval between successive intervals of actual egg-laying. This checks fairly well with the figure offered above for the interval between the appearance of successive broods of callows, as it obviously should.

To repeat, there is every reason to believe that in a given hamatum colony the broods appearing at intervals of about 35 days are the progeny of a single queen. Not only the facts concerning the capture of queens, but also the highly predictable time relations between successive broods, support this conclusion. The facts as sketched in Figure 2 indicate that the entire set of events is highly synchronized; particularly in the ability of the queen to deliver a new batch of eggs about 12 days before the previous brood joins the worker population of the colony. The evidence suggests that in our area of study a given hamatum queen is capable of repeating this process a number of times during the first months of the rainy season and perhaps even longer.

Thus in an indirect manner but nevertheless very effectively the queen is the pace-setter of the cyclic changes which have been described for the type species. This relationship appears to hold for other *Eciton s. str.* species as well (*e.g.*, *E. burchelli*, *E. vagans*), and perhaps also in other *Eciton* subgenera.

To summarize, in *hamatum* we seem to have the master pattern, as it were: 1) the queen at regular intervals and in a strikingly precise manner furnishes a huge mass of eggs which begin their development almost simultaneously, 2) the given brood does not materially influence events until the emergence of the previous brood as callows dynamizes the population into nomadism, 3) then the new brood (as larvæ) takes over as principal source of

the "social stimulation" which maintains the highly dynamic activity pattern of the colony for some time; 4) when the "drive" effect of the larval brood is removed as it enters the pupal condition the colony lapses into its minimal activity pattern, from which 5) the emergence of this brood as callow workers arouses it into a new dynamic phase—and so on.

The queen is the key of this entire process, but only in an indirect manner through her physiological properties as the producer of successive broods. After a given brood has appeared as eggs we may say hypothetically that the presence of the queen is essential neither for the next major change in colony behavior nor for the maintenance of this change (*i.e.*, for nomadism). In fact without the queen the next sessile phase of the colony-behavior cycle may also occur and the colony will even begin its next nomadic period (*cf.* Fig. 2). However, if no new brood is forthcoming we should expect the colony to lapse from its new nomadic phase into an aberrant and mainly sessile type of existence, *i.e.*, a protracted statary condition. Some evidence corroborating this prediction is in fact available from the study of colonies deprived of their broods.

To state the hypothesis in a different way, it is quite likely that in the dry season when Eciton broods are very small (either through metabolic insufficiency in the queen or through brood cannibalism in the workers, or both of these), the colonies lapse almost completely into statary life. But under optimal conditions in the rainy season, the adequate condition and regular labors of the queen periodically furnish the colony, in an incidental manner, with the changes in trophallaxis-based social stimulation which condition the drive (or lack of drive) underlying alternate changes in the general behavior cycle.

The exquisite synchronization of the set of relationships involved in the Eciton behavior pattern is emphasized in several ways when the queen is considered in her rôle of key individual. Through her capacity to deliver an entire batch of eggs within a few days, the queen indirectly contributes the precision with which the colony shifts from one mode of life to another. This in turn promotes a further characteristic of great adaptive value. Due to the spacing of her successive broods, the queen becomes

physogastric and lays her eggs *only at times when the colony happens to be statary* (see Fig. 2), a combination of events which is most opportune for survival of colony and species. It is apparent from our discussion of the indirect relations existing between the cycles of queen and colony functions that a true *convergence* of events occurs in this case, which serves to guard the queen from injury at the one time she is most vulnerable. When she is gravid, having to make her way over a long bivouac-change trek undoubtedly would offer a serious risk for the queen, carrying the constant threat of dangers such as a tumble from elevated sections of the path on vines or tearing the tightly stretched intersegmental membranes on rough surfaces. Instead, thanks indirectly to her own visceral regularity, the queen is safely immured through this critical period, and moreover, there follows a further time of safety during which she may convalesce from the organic ordeal of large-scale oviposition. Not least among the factors fitting into the marked adaptivity of this synchronized pattern of events, the bivouac of the colony in its statary phase is characteristically more sequestered than at other times. Altogether, it would be difficult to find a more effectively adaptive mosaic of various biological events than this one, based upon the physiological properties of the Eciton queen.

SUMMARY AND CONCLUSIONS

The functions of the *Eciton hamatum* queen serve indirectly as a pace-making factor in the colony behavior pattern of the species.

The determining processes in a given colony center around the reproductive properties of the single functional queen. Except when colony bivouac-change movements occur the fertile queen is confined to the bivouac, evidently to a large extent because of her pronounced photonegativity. At regular intervals of approximately 35 days the dichthadiigyne becomes physogastric and within a few days releases a mass of more than 20,000 eggs. Between egg-delivery episodes she remains in the contracted or "resting" condition. The ability of the hamatum queen to mature and deliver an immense number of eggs within a very limited time means that all members of a given brood develop

and mature roughly in synchronization. These facts hold important consequences for the colony behavior pattern.

In the rainy season of the Caribbean lower rain-forest zone of Panama, a colony of *E. hamatum* passes through statary (minimal raiding; absence of migration) and nomadic (maximal daily raiding; successive daily bivouac-changes) behavior phases at regular intervals, each period lasting nearly 20 days. Depending upon the properties of a fertile queen, the alternation of these behavioral phases is highly predictable.

Significantly different intracolony circumstances parallel the two phases of the colony behavior cycle. Colonies in the nomadic condition invariably contain a single brood passing through its larval stage, and the period ends precisely when this brood has become mature and is mainly enclosed in cocoons. In statary colonies a brood in the pupal stage is found, and the period ends when this brood has matured and has mainly emerged as callow workers. Approximately seven days after a given statary period has begun, a new brood of more than 20,000 eggs appears.

The intimate correspondence which exists between Eciton colony behavior and brood condition is explicable in terms of the Wheeler *trophallaxis* concept. Evidence is cited for the involvement of a special social-stimulative effect, a superadded "drive" factor, furnished by broods capable of extensive overt activity. Emanating from a newly emerged lot of callow workers, this effect arouses a previously sessile colony to the threshold of maximal raiding and daily bivouac-change, and thus is responsible for initiating a new nomadic period. Furthermore, due to a rather precise synchronization of successive broods, before the energizing function of a new callow brood runs its course it is overlapped and succeded by the similar function of a sufficiently developed larval brood. This larval effect maintains the nomadic condition over a considerable time, but the colony lapses promptly from nomadism when the larvæ mature and spin their cocoons. Thus the sessile and relatively inactive statary condition which ensues is attributable to the existence of an inadequate energization of the colony when the brood (eggs; pupæ) is incapable of functioning as an effective source of social stimulation.

Periodic changes characterizing Eciton colony behavior thus basically depend upon a highly regular reproductive cycle in the

queen. By furnishing new broods at fixed intervals, the queen's function indirectly governs the presence or absence of the intra-colony dynamizing factor critically responsible for the ebb and flow of events in the Eciton behavior pattern.

LITERATURE CITED

ANDRÉ, E. 1885. Species des Hyménoptères. (Supplement au species des Formicides d'Europe et des pays limitrophes.) 8: 838–840.

BRUCH, C. 1934. Las formas femeninas de *Eciton* . . . Descripcion y re-descripcion de algunas especies de la Argentina. Ann. Soc. Cient. Argent., 118, 2nd sem., 1934: 113–135.

EMERSON, A. E. 1939. Social organization and the superorganism. Amer. Midl. Nat., 21: 182–209.

GALLARDO, A. 1920. Las hormigas de la República Argentina—Subfamilia dorilinas. Anal. Mus. Nac. Hist. Nat. Buenos Aires, 30: 281–410.

MÜLLER, W. 1886. Beobachtungen an Wanderameisen (*Eciton hamatum* Fabr.).[19] Kosmos, 18: 81–93.

REICHENSPERGER, A. 1926. Das ♀ von *Eciton mattogrossensis* Luederw. (Hym.) Ent. Mitteil., 15: 401–404.

———. 1934. Beitrag zur Kenntnis von *Eciton lucanoides* Em. Zool. Anz., 106: 240–245.

SCHNEIRLA, T. C. 1933. Studies on army ants in Panama. Jour. Comp. Psychol., 15: 267–299.

———. 1934. Raiding and other outstanding phenomena in the behavior of army ants. Proc. Nat. Acad. Sci., 20: 316–321.

———. 1938. A theory of army-ant behavior based upon the analysis of activities in a representative species. Jour. Comp. Psychol., 25: 51–90.

———. 1940. Further studies on the army-ant behavior pattern. Mass organization in the swarm-raiders. *Ibid.*, 29: 401–460.

———. 1944. Studies on the army-ant behavior pattern. Nomadism in the swarm-raider *Eciton burchelli*. Proc. Amer. Phil. Soc., Phila., 89 (1) (in press).

WEBER, N. 1941. The rediscovery of the queen of *Eciton* (*Labidus*) *coecum* Latr. (Hym.: *Formicidæ*). Amer. Midl. Nat., 26: 325–329.

WERRINGLOER, ANNELIESE. 1932. Die Sehorgane und Sehzentren der Dorylinen nebst Untersuchungen über die Facettenaugen der Formiciden. Zeitschr. wiss. Zool., 141: 432–524.

WHEELER, G. C. 1943. The larvæ of the army ants. Ann. Entom. Soc. Amer., 36: 319–332.

WHEELER, W. M. 1900. The female of *Eciton sumachrasti* Norton, with some notes on the habits of Texas Ecitons.[20] Amer. Nat., 34: 563–574.

[19] Redetermined as *E. burchelli.*

[20] Redetermined as *E. schmitti.*

———. 1910. Ants, their Structure, Development and Behavior. N. Y.: Columbia University Press. pp. 663.

———. 1921. Observations on army ants in British Guiana. Proc. Amer. Acad. Arts Sci., 56: 291–328.

———. 1925. The finding of the queen of the army ant *Eciton hamatum* Fabricius. Biol. Bull., 49: 139–149.

———. 1928. The social insects, their origin and evolution. N. Y.: Harcourt, Brace.

——— AND I. W. BAILEY. 1920. The feeding habits of Pseudomyrminæ and other ants. Trans. Amer. Phil. Soc., 22, N.S., Art. 4: 235–279.

ZAHL, P. A. 1939. To the Lost World. N. Y.: Knopf.

A RE-SURVEY OF PAPAIPEMA SM. (LEPIDOPTERA)

BY HENRY BIRD
RYE, N. Y.

The intricacies of insect life are abysmal and any individual studies are bound to be incomplete and fragmentary. This is so axiomatic as to need no argument and may excuse the limited viewpoint of any single observer. However, as time goes on data and observable facts accumulate, given problems here and there gain enlightenment through various channels.

Retrospective deductions on the part of the writer based on "the sum of evidence" as this slowly evolves apparently offers some ground work for the serial arrangement of *Papaipema* species.

Conceived as an ontogenetic tree with its phylogenetic roots outcropping from supposedly more ancient genera, it is interesting to invade this vale of surmise.

To what extent these relationships can be shown in a list arrangement is unsatisfactory but should be undertaken. As building bricks there are the characters of the adults including of course the genitalia of both sexes, the gleaning from larval evidence backed by attending factors. Thus it becomes requisite to discourse somewhat at length taxonomically.

Also the final disposition of holotypes should be chronicled.

First, as to the generic basis whereupon Prof. J. B. Smith established *Papaipema* in 1899.[1]

He named no genotype and the gist of his characterizations featured moths with primaries rather broad and outwardly acute at apex; the thoracic tuftings decidedly upright and anteriorly usually broadened, in form like an "adze" behind the collar; the antennæ are simple; the frons smooth; the male genitalia mainly show a unique pattern "having the harpes more or less forked with triangular patch of spinulated surface at the tip. The clasper in almost all cases a long, stout, curved hook, but is unique in having the outer curve strongly toothed."

[1] Revision of Hydroecia, Trans. Am. Ent. Soc., Vol. XXVI.

As now considered there are nearly fifty species in the genus with thirty-seven at least following this genitalic pattern closely. Smith's simple drawings of a portion of the male genitalia are misleading however since it is necessary to chronicle the following specific errors.

Harrisii and *pterisii* were considered by him as one species; *duovata, arctivorens* and *merriccata* at least were confused under "*rutila*"; *circumlucens, ochroptena* and form *humuli* were treated as *circumlucens;* he considered *cerussata* and *frigida* form *thalictri* under *cerussata* label; treated *purpurifascia* and *lysimachiæ* as one; misidentified *sciata* for "*limpida*"; *nepheleptena* for *appassionata,* while his reference to *necopina* had largely to do with *maritima.*

Criticism should not be levied unduly at these presumed mistakes since some of Guenee's types, notably *rutila* and *limpida,* British Museum uniques, have not been satisfactorily associated, and two of our names as used hereinafter will probably fall through this lack of perception.

In 1910 Sir George Hampson,[2] following his custom of citing genotypes, selected *cerina* as genotype of *Papaipema,* on First Species Rule because it headed Smith's enumeration of the genus. That was an unfortunate usage since the species does not measure fully to Smith's definition. Recognizing this discrepancy from a mere autopic glance, and though bound by the Rules he nevertheless uses the very proper species *harrisii* in illustrating venation and the bodily detail, quite representative of the genus.

Begging Sir George's pardon, this writer votes that *cerina* Grt. be superseded as genotype of *Papaipema* by *harrisii* Grt., if a more elastic rule be forthcoming some day.

The limitations of generic boundaries are subject to varying personal ideas but ideally their demarcation should suggest evolutionary trends in so far as that might be surmised.

Avoiding theory as much as possible but judging facts as they appear today, we can find much aid in turning to the larvæ in their earlier stages.

It is generally conceded that early stage larvæ reflect the primitive ancestral line at least phylogenetically. Leaning on this

[2] Cat. Lep. Phal. Brit. Mus., Vol. IX, p. 80.

deduction, a personal familiarity with forty *Papaipema* species seems to help in some measure while details of color pattern aid specifically. As larvæ *Papaipema* species are unique.

Their early larval pellicle is distinctly colored whereas most mining larvæ are at all stages more or less translucent.

The great majority show a contrasting middle ring of dark purplish or pinkish brown, in livid hue, at the first four abdominal segments while elsewhere longitudinal white or yellowish lines drawn on the darker body color produce striking individuals.

This intensity continues through the instars up to the penultimate, while maturity usually exhibits a faded translucence.

Three pattern types follow; the dark middle girdle may show an abrupt termination of all lines; or the dorsal line may cross it in unbroken continuity; or both the dorsal and subdorsal may be entirely unbroken. These features of pattern aid much specifically.

They are constant with two exceptions—the Pacific Coast species *angelica* and *insulidens*, where one, or rarely both lines may be continuous. One is tempted to assume that a progenitor was not wholly an internal feeder but subsisted within some encircling tissues with both extremities exposed and maintaining there the linear markings. The above category applies to thirty-eight known individuals. Two other known species are decidedly different and, again assuming, feature as admirable connecting links with their *Apamea-Gortyna-Hyroecia* relatives possessing a world-wide, north temperate zone dispersal. Because of this dispersal as against restricted North American *Papaipema* it seems rational to consider the latter as a subsequent offshoot. Their very close relationship bespeaks a comparatively recent evolution wherein possibly marked choices of food plants, some of the latter also restricted to America, may have played a part in influencing specific origin.

The larvæ of the two alleged connecting species, *frigida* and *beeriana* have their markings as transverse segmental rings, features prevailing with *Apamea erepta ryensis, Hydrœcia immanis, H. micacea* and *H. stramentosa,* which is as far as familiarity goes.

The exotic *Xanthœcia flavago* larva is cross banded, while *Parapamea buffalœnsis* and *Embolœcia sauzalitœ* have larvæ

which are longitudinally lined. This latter trio has the frons distinctly armed but these various genera may all figure as part of the "Gortynid series." This term has been used by the writer as a convenience, and in view of Grote's arguments,[3] *Gortyna*, genotype *micacea* Och., might properly find generic application somewhere therein.

As structural larval features, the heavy setigerous plates are noteworthy, with a peculiar development in many species that have an additional plate known as IVa, on joint ten. Since this plate bears no setal hair its transitory character may be adduced. However it is one of the evidences aiding specific distinction.

The rugged genitalia become a prime structural feature with the adults. In the males such closeness to the conventional pattern prevails as to indicate the very near relationship of the species. Greatest modification exists with *furcata* and *eryngii*, while *frigida*, *unimoda* and *appassionata* make a decided break with the harpes greatly reduced. One might suggest a generic break here but full evidence points to connecting species.

With the female genitalia the genital plate at the ostium is of help specifically. It is a heavy, more or less shield-shaped process, differing in outline and scobinated characteristically. Dr. F. Heydemann in a praiseworthy treatment of the *nictitans* group of *Apamea*[4] notes the value of the genital plate and figures the character without other detail upon a single plate for specific comparison.

The close proximity of *Papaipema* species blend them together into a satisfactory whole. Indeed, in a number of instances they are so close that if no further evidence was at hand than a few flown specimens much doubt would arise as to their distinction.

Furthermore, variation is rife particularly in the feature wherein the ordinarily prominent white marked stigmata may be obsolescent or vice versa. This is productive of such an autopic difference that erroneously, two distinct species seem to be involved—vide Guenee's two alleged species, *nebris* and *nitela*.

That a varietal name be given to the lesser of such forms seems practical. This has been done in the more striking instances and

[3] Historical Sketch of Gortyna, Proc. Am. Phil. Soc., Vol. XXXIX, No. 162.

[4] Die Arten der *Hydroecia nictitans*. Sond. Ento. Zeit., XXXXIX u. XXXXV.

the future holds possibilities with slighter stigmatal variance likely to be grasped by some. Some dimorphism is observable, the ubiquitous *cataphracta* with its extensive food habits shows this in its more northern range, while *imperspicua* represented by a unique type may well be in that category. Until rearing proves the fact its specific standing may remain.

Two formerly considered species must merge as one, *verona* and *astuta* with the latter name preserved as varietal. Smith's unique type of *verona*, from Winnipeg, Manitoba, is a dwarfed pale form of the species, while *astuta* was applied to a larger more colorful variant with the terminal space solidly purplish, easily suggestive of distinctness. Both can occur in the same locality and though *verona* is less numerous in the writer's experience; it has priority.

That *astuta* be retained as a distinct color, or dimorphic form points to future expediency.

As to the placement of *Papaipema* holotypes, the writer has prepared a detailed treatment of the genus under title "The Epic of Papaipema," a unique copy which is willed to the American Museum of Natural History, New York, N. Y.

With it will go his collection of the group. Hence the holotypes and paratypes, with the relevant literature will be at one place for future students. The collection embraces something over fifteen hundred specimens, mainly reared. The various types number ninety-eight examples. The aggregation brings together not only the adults, but larval and pupal stages, to some extent the parasites; the foodplant habitations are also shown. The genitalic slides are not considered in this summary.

The "Epic" consists of three volumes. It assembles the principal published literature thus dealing with the historic rise and subsequent departures in the genus, treats monographically, matters of taxonomic import, features of parasitism and the gleanings of several decades of field study. Interlarded between the published papers, the author's notes and criticisms bring such up to current review. Particularly some of his earlier papers were rather puerile and in need of revision. Volumes I and II total 1127 pages, inclusive of the relevant articles. Volume III is a portmanteu affair.

Seventy plates occupying seven containers, are unbound for easy comparison; four containers hold autographed letters from important workers in connection with the subject, many of whom have now passed on. The plates illustrate by line drawings the infested food plants in some instances, larval features and the genitalia of both sexes in so far as possible, while the adults are shown in color. There is also a booklet of remarks and index of plates.

By what manner a commingling of the species of *Papaipema* can be best portrayed with their ontogenetic proximity apparently shown, it is convenient to resort to a popular vegetative process and erect a fanciful "tree."[5] Then, as nonconventional genes seem to have effected the protoplasmic stream, branches or shoots may materialize, either ascending or paralleling the main trunk according to the line of thought. Admirable as a basis of ideas, but to transplant this fruitage to the linear order of list column spoils the conception entirely. The writer can only suggest the following summary.

List order for the species of the genus

PAPAIPEMA Smith.

(Asterisk denotes larva unknown, synonyms in italics)

frigida Smith.
form thalictri Lyman.
terminalis Strand.
unimoda Smith.*
beeriana Bird.
form lacinariæ Bird.
appassionata Harvey.
horni Strand.
purpurifascia Grote & Robinson.
luteipicta Strand.
lysimachiæ Bird.
nec purpurifascia Auct.
stenoscelis Dyar.
speciosissima G. & R.
form regalis Wyatt & Beer.
inquæsita G. & R.
form wyatti Barnes & Benjamin.
pterisii Bird.
triorthia Dyar.
anargyria Dyar.*
ochroptena Dyar.
form humuli Bird.
arctivorens Hampson.
merriccata Bird.
araliæ Bird & Jones.
harrisii Grote.
form mulieris Strand.
sub. sp. **rubiginosa** Bird.
verona Smith.
form **astuta** Bird.

[5] EPIC OF PAPAIPEMA, 1940, pp. 553–554, Vol. II.

rutila Guenee.*
depictata Benjamin.*
nepheleptena Dyar.
moeseri Bird.
impecuniosa Grote.
circumlucens Smith.
baptisiæ Bird.
form ochroptenoides Benj.*
sub. sp. vaha Benj.*
marginidens Guenee.
birdi Dyar.
nephrasyntheta Dyar.*
furcata Smith.
rigida Grote.
pertincta Dyar.
limata Bird.*
insulidens Bird.
angelica Smith.
cataphracta Grote.
form sulphurata Bird.
race fluxa Bird.
imperspicua Bird.*
duovata Bird.
ærata Lyman.
placida Bird.*
cerina Grote.
dribi Benjamin.*
polymniæ Bird.
nebris Guenee.
form nitela Guenee.
duplicata Bird.
obsolescens Strand.
silphii Bird.
necopina Grote.
nelita Strecker.
form linda Bird.
form obicularis Strand.
errans Barnes & McDunnough.
engelhardti Bird.
sciata Bird.
limpida Guenee.*
cerussata Grote.
eryngii Bird.
maritima Bird.
eupatorii Lyman.

INSECT INTRODUCTIONS AND WAR

The recent press releases on the introduction of potential insect pests in packages sent home by members of the armed forces overseas has evidently stirred some interest. The Bureau of Plant Industry, New Jersey Department of Agriculture, was called to inspect and fumigate a reed stool received by a woman in Trenton, New Jersey from her son in India. This was found to be infested with numerous small bostrichid beetles which were identified by W. S. Fisher, Bureau of Entomology and Plant Quarantine at Washington, D. C., as *Dinoderus brevis* Horn. *D. brevis* was originally described from a single specimen taken in Louisiana, and was believed to be a native species. This species was later found to be Oriental, especially common in India, and has been carried, through commerce, to many parts of the world.—William M. Boyd.

CATALOGUE OF NORTH AMERICAN PSYCHODIDÆ

BY WILLIAM F. RAPP, JR.

In 1905 Aldrich[1] published the last catalogue of North American Diptera. In the family Psychodidæ he listed 34 species, which were distributed in four genera. Table I is a comparison of Aldrich's 1905 catalogue and this catalogue.

TABLE I

Genus	Aldrich 1905	Rapp 1943
Flebotomus		3
Pericoma	11	13
Psychoda	21	41
Sycorax	1	
Trichomyia	1	2
No. of species	34	59

Since 1905 several workers have been attracted to this family with the result that many changes have arisen in nomenclature, plus the addition of new species. This catalogue has been compiled after a careful survey of the entomological literature. Synonymy is listed wherever it has appeared in the literature. It is interesting to note that of the 34 species listed by Aldrich only 6 have been reduced to synonymy. Of the 54 species described since 1905, 19 have proven to be synonyms.

The North American Psychodidæ, as a whole, are of little economic importance. Certain species of Flebotomus are known vectors of tropical diseases, but none of these occur in the North American region. *Psychoda alternata* Say is at times a pest around sewage filter plants.[2]

The area covered in this paper includes all of America north of Mexico, or the area considered as the nearctic region based upon zoogeographical division.

1 Aldrich, John M. "A Catalogue of North American Diptera," *Smithsonian Miscellaneous Collections*, Vol. 46 (1905), p. 1–680.

2 Headlee, T. J., and Beckwith, C. S., "Sprinkling Sewage Fly, *Psychoda alternata*," Jour. Econ. Ent., Vol. 11 (1918), p. 395–401.

FLEBOTOMUS* Rondani

Flebotomus diabolicus Hall.
Phlebotomus diabolicus Hall, Proc. Ent. Soc. Wash., Vol. 38 (1936), p. 28.
Texas.

Flebotomus texanus Dampf.
Phlebotomus texanus Dampf, Anales de la Escuela Nacional de Ciencias Biologicas, Vol. 1 (1938), pp. 119–122.
Texas.

Flebotomus vexator Coquillett.
F. vexator Coquillett, Ent. News, Vol. 18 (1907), p. 102.
Louisiana, Maryland.

PERICOMA Walker

Pericoma bipunctata Kincaid.
P. bipunctata Kincaid, Ent. News, Vol. 10 (1899), p. 34.
California, Washington.

Pericoma californica Kincaid.
P. californica Kincaid. Ent. News, Vol. 12 (1901), p. 195.
California.

Pericoma carolina Banks.
P. carolina Banks, Bul. Brooklyn Ent. Soc., Vol. 26 (1931), p. 228.
North Carolina.

Pericoma furcata Kincaid.
P. furcata Kincaid, Ent. News, Vol. 10 (1899), p. 34.
Washington.

Pericoma longiplata Haseman.
P. longiplata Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 308.
Arizona.

Pericoma ocellaria var. **americana** Kincaid.
P. ocellaria var. *americana* Kincaid, Ent. News, Vol. 12 (1901), p. 194.
Maine.

Pericoma satellitia Dyar.
P. satellitia Dyar, Proc. Ent. Soc. Wash., Vol. 29 (1927), p. 163.
Maryland.

* *Phlebotmus* of authors.

Pericoma scala Haseman.

P. scala Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 307.

Arizona.

Pericoma sitchana Kincaid.

P. sitchana Kincaid, Ent. News, Vol. 10 (1899), p. 33.

Alaska, Oregon.

Pericoma trialbawhorla Haseman.

P. trialbawhorla Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 306.

Missouri.

Pericoma triloba Kincaid.

P. triloba Kincaid, Ent. News, Vol. 10 (1899), p. 33.

Washington.

Pericoma truncata Kincaid.

P. truncata Kincaid, Ent. News, Vol. 10 (1899), p. 35.

California.

Pericoma variegata Kincaid.

P. variegata Kincaid, Ent. News, Vol. 10 (1899), p. 33.

Washington.

PSYCHODA Latreille

Psychoda alberta Curran.

P. alberta Curran, Can. Ent., Vol. 56 (1924), p. 219.

Alberta.

Psychoda albipunctata Williston.

P. albipunctata Williston, Ent. News, Vol. 5 (1893), p. 113.

Telmatoscopus meridionalis Eaton, Ent. Mo. Mag. (1894), p. 195.

P. snowii Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 311–312.

P. crecta Curran, Cat. Ins. Jam. Dept. Agr., Jamaica Ent. Bul. No. 4, pt. 1 & 2 (1926), p. 102.

Florida, Louisiana, South Carolina, Texas.

Psychoda albitarsis Banks.

P. albitarsis Banks, Can. Ent., Vol. 27 (1895), p. 324.

Maryland, New Jersey, New York, North Carolina, Virginia. Quebec.

Psychoda alternata Say.

P. alternata Say, Long's Exp. St. Peter's River, App. (1824), p. 358.

Tipula phalæmoides Scop., Ent. Carn., No. 864 (1763), p. 324.

Psychoda sexpunctata Curtis, Brit. Ent., Vol. 16 (1839), p. 745.

P. marginepunctata Roser., Corr. Wurt. landro, Ver. 1 (1840), p. 50.

P. schizura Kincaid, Ent. News, 10 (1899), p. 32.

P. floridica Haseman, Trans. Am. Ent. Soc., 33 (1907), p. 316.

P. nocturnala Haseman, Trans. Am. Ent. Soc., 33 (1907), p. 319.

P. bengalensis Brunetti, Rec. Ind. Mus., Vol. 11 (1908), p. 370.

P. albimaculata Welch, Ann. Ent. Soc. Amer., Vol. 5 (1912), p. 411.

P. dakotensis Dyar, Insec. Inscit. Menst., Vol. 14 (1926), pp. 107–110.

California, Connecticut, District of Columbia, Florida, Illinois, Kansas, Maryland, Missouri, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, South Dakota, Texas, Virginia, Washington.

Psychoda annulipes Johnson.

P. annulipes Johnson, Bul. Amer. Mus. Nat. History, Vol. 32 (1913), p. 43.

Florida.

Psychoda aterrima Banks.

P. aterrima Banks, Ent. News, Vol. 25 (1914), p. 128.

New York.

Psychoda augusta Curran.

P. augusta Curran, Can. Ent., Vol. 58 (1926), p. 228.

Quebec.

Psychoda autumnalis Banks.

P. autumnalis Banks, Ent. News, Vol. 25 (1914), p. 127.

Pericoma littoralis Dyar, Insec. Inscit. Menst., Vol. 14 (1926), pp. 107–110.

Pericoma aldrichana Dyar, Insec. Inscit. Menst., Vol. 14 (1926), pp. 107–110.

California, District of Columbia, Maryland, Virginia.
Alaska.

Psychoda bicolor Banks.
P. bicolor Banks, Can. Ent., Vol. 26 (1894), p. 33.
P. nigra (Banks) Dyar, Proc. Ent. Soc. Wash., Vol. 30 (1928), p. 87.
District of Columbia, Indiana, Maryland, New York.

Psychoda bishoppi Del Rosario.
P. bishoppi Del Rosario, Philippine Jour. Sci., Vol. 59 (1936), p. 141.
Maryland.

Psychoda cinerea Banks.
P. cinerea Banks, Can. Ent., Vol. 26 (1894), p. 331.
P. elegans Kincaid, Ent. News, Vol. 8 (1897), p. 144.
Threticus compar Eaton, Ent. Mo. Mag. II, Vol. 15 (1904), p. 57.
P. domestica Haseman, Ent. News, Vol. 19 (1908), p. 285.
P. compar Tonnoir, Ann. Soc. Ent. Belg., Vol. 62 (1922), p. 67.
P. prudens Curran, Can. Ent., Vol. 56 (1924), p. 219.
Connecticut, District of Columbia, Indiana, Maine, Maryland, Massachusetts, Missouri, New Jersey, New York, Oregon, Virginia, Washington.
Alberta.

Psychoda criddlei Curran.
P. criddle Curran, Can. Ent., Vol. 56 (1924), p. 218.
Ontario.

Psychoda degenera Walker.
P. degenera Walker, List of the Specimens of Dipterous Insects in the Collection of the British Museum, List I (1848), p. 33.
Ontario.

Psychoda helicis Dyar.
P. helicis Dyar, Proc. Ent. Soc. Wash., Vol. 31 (1929), p. 63.
Maryland.

Psychoda horizontala Haseman.
P. horizontala Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 313.
Missouri.

Psychoda interdicta Dyar.

P. interdicta Dyar, Proc. Ent. Soc. Wash., Vol. 30 (1928), p. 88.

Maryland, New York.

Psychoda interrupta Banks.

P. interrupta Banks, Proc. Ent. Soc. Wash., Vol. 8 (1907), p. 150.

Maryland.

Psychoda juno Curran.

P. juno Curran, Can. Ent., Vol. 58 (1926), p. 228.

Ontario.

Psychoda longifringa Haseman.

P. longifringa Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 318.

Florida.

Psychoda marylandana Del Rosario.

P. marylandana, Del Rosario, Philippine Jour. Sci., Vol. 59 (1936), p. 111.

Maryland.

Psychoda megantica Curran.

P. megantica Curran, Can. Ent., Vol. 56 (1924), p. 217.

Quebec.

Psychoda minuta Banks.

P. minuta Banks, Can. Ent., Vol. 26 (1894), p. 331.

Connecticut, New Jersey, New Mexico, New York, Virginia.

Psychoda nigra Banks.

P. nigra Banks, Can. Ent., Vol. 26 (1894), p. 331.

P. marginalis Banks, Can. Ent., Vol. 26 (1894), p. 333.

P. apicalis Banks, Proc. Ent. Soc. Wash., Vol. 8 (1906), p. 148.

P. basalis Banks, Proc. Ent. Soc. Wash., Vol. 8 (1906), p. 149.

Pericoma orillia Curran, Can. Ent., Vol. 56 (1924), p. 218.

P. varitarsis Curran, Can. Ent., Vol. 56 (1924), p. 220.

Maruina nigra (Banks) Dyar, Insec. Inscit. Menst., Vol. 14 (1926), p. 111.

Pericoma apicalis (Banks) Dyar, Insec. Inscit. Menst., Vol. 14 (1926), p. 149.

Connecticut, District of Columbia, Indiana, Maine, Mary-

land, New Hampshire, New Jersey, New York, Ohio, Virginia.

Ontario, Quebec.

Psychoda nitida Banks.

P. nitida Banks, Can. Ent., Vol. 33 (1901), p. 275.

District of Columbia, New York.

Psychoda olympia Kincaid.

P. olympia Kincaid, Ent. News, Vol. 8 (1899), p. 144.

Pericoma olympia (Kincaid) Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 305.

Washington.

Psychoda opposata Banks.

P. opposata Banks, Can. Ent., Vol. 33 (1901), p. 274.

District of Columbia, Maryland, New York.

Psychoda phalæmoides (Linn.) Tonnoir.

Tipula phalænoides Linnaeus, Syst. Nat. ed. 10, No. 32 (1758), p. 588.

P. phalænoides (Linn.) Tonnoir, Ann. Soc. Ent. Belg., Vol. 62 (1922), p. 67.

P. pacifica Kincaid, Ent. News, Vol. 8 (1897), p. 143.

P. tonnoiri Dyar, Insec. Inscit. Menst., Vol. 14 (1926), p. 105.

California, Colorado, District of Columbia, Idaho, Maryland, New Mexico, Oregon, Washington, Wisconsin.

Alberta, British Columbia.

Alaska.

Psychoda pusilla Tonnoir.

P. pusilla Tonnoir, Ann. Soc. Ent. Belg., Vol. 62 (1922), p. 83.

Kansas, Maryland.

Psychoda quadripunctata Banks.

P. quadripunctata Banks, Ent. Soc. of Wash., Vol. 8 (1907), p. 149.

Virginia.

Psychoda scotiæ Curran.

P. scotiæ Curran, Can. Ent., Vol. 56 (1924), p. 216.

Nova Scotia, Quebec.

Psychoda severini Tonnoir.

P. severini Tonnoir, Ann. Soc. Ent. Belg., Vol. 62 (1922), p. 78.

California, District of Columbia, Maryland, Montana, New Mexico.

British Columbia.

Psychoda sigma Kincaid.

P. sigma Kincaid, Ent. News, Vol. 10 (1901), p. 31.

P. surcoufi Tonnoir, Ann. Soc. Ent. Belg., Vol. 62 (1922), p. 74.

Washington.

Psychoda signata Banks.

P. signata Banks, Can. Ent., Vol. 33 (1901), p. 274.

District of Columbia, Maine.

Psychoda slossoni Williston.

P. slossoni Williston, Ent. News, Vol. 4 (1893), p. 114.

Maine, New York.

Psychoda snowhilli Del Rosario.

P. snowhilli Del Rosario, Philippine Jour. Sci., Vol. 59 (1936), p. 140.

Maryland.

Psychoda squamosa Johnson.

P. squamosa Johnson, Bul. Amer. Mus. Nat. Hist., Vol. 32 (1913), p. 43.

Psychoda superba Banks.

P. superba Banks, Can. Ent., Vol. 26 (1894), p. 332.

District of Columbia, Maryland, Michigan, New Jersey, New York, Virginia.

Psychoda superba var. **conspicua** Del Rosario.

P. superba var. *conspicua* Del Rosario, Philippine Jour. Sci., Vol. 59 (1936), p. 125.

Maryland, Virginia.

Psychoda tridactila Kincaid.

P. tridactila Kincaid, Ent. News, Vol. 19 (1899), p. 32.

Washington.

Psychoda uniformata Haseman.

P. uniformata Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 319.

Missouri.

Psychoda uniformis Del Rosario.
P. uniformis Del Rosario, Philippine Jour. Sci., 59 (1936), p. 113.
Maryland.

TRICHOMYIA Haliday

Trichomyia lanceolata Kincaid.
Sycorax lanceolata Kincaid, Ent. News, Vol. 10 (1899), p. 35.
California, Washington.

Trichomyia unipunctata Haseman.
T. unipunctata Haseman, Trans. Am. Ent. Soc., Vol. 33 (1907), p. 323.
Arizona.

RECENT WORK BY THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

BY FRANCIS HEMMING

SECRETARY TO THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

The International Commission on Zoological Nomenclature are now engaged in the publication of decisions taken before the outbreak of war in 1939. These decisions have been embodied in *Opinions* 134–183 and *Declarations* 10–12. Of these, *Opinions* 134–155 and the 3 *Declarations* have already been published or are in the press. The remainder are ready for printing and will be published as soon as funds are available.

These *Opinions* are of particular interest to entomologists, since in addition to 9 *Opinions* relating to the interpretation of various aspects of the International Code, no less than 38 of these *Opinions* are directly concerned with entomological subjects.

The *Opinions* relating to the interpretation of the Code are: *Opinion* 138 (meaning of phrase "definite bibliographic reference" in Article 25); *Opinion* 141 (naming of families); *Opinion* 145 (status of names first published in invalid works); *Opinion* 147 (generic names of same origin and meaning as older generic names); *Opinion* 148 (status relating to names published as emendations of, or substitutes for, older names); *Opinion* 164 (position as regards types when two or more genera are united); *Opinion* 168 (supplementing *Opinion* 65 regarding genera based upon erroneously determined species); *Opinion* 172 (status of type—designations of genera in abstracts, etc.); and *Opinion* 183 (interpretation of Article 8 relating to form in which generic names should be published).

Of the *Opinions* specially concerned with entomological subjects, 6 deal with the status of particular works or with the dates of such works: *Opinion* 136 (Latreille, 1810) affects all Orders of insects; *Opinion* 135 ("Erlangen List," 1801) is of special interest to hymenopterists; *Opinions* 134 (Freyer, *Neue Beiträge*), 138 (Hübner, *Samml. exet. Schmett* 1807 and Fabricius *Mag.*

Insektenk. (Illiger) 1807) and 150 (Hübner, *Verz. bek. Schmett*) are concerned with Lepidoptera and *Opinion* 152 (Meigen, 1800) with Diptera. *Opinions* 140 and 143 deal with certain family names in insects.

The remaining 30 *Opinions* deal with particular generic names in various Orders of insects. These *Opinions* either fix the types of these genera or add the names to the *Official List of Generic Names in Zoology*, or do both. Three of these *Opinions* are concerned with Orthoptera; 13 with Hymenoptera and 14 with Lepidoptera.

Each *Opinion* is published separately but *Opinions* are consecutively paged to facilitate the publication of an index on the completion of the volume concerned.

The International Commission are most anxious to secure that *Opinions* are published as rapidly as possible but they are greatly hampered by lack of funds. The Commission therefore appeal to scientific institutions and individual scientific workers for donations to a special fund to be used for the issue of publications. Full particulars of this Appeal are given in Part 2 of the Commission's Official Organ, the *Bulletin of Zoological Nomenclature* published in 1943.

Contributions, however small, will be warmly welcomed and will be acknowledged in the *Bulletin*. Bankers' drafts, cheques, and money orders should be made payable to the "International Commission on Zoological Nomenclature" and sent to the Commission at their Publications Office, 41 Queen's Gate, London, S.W.7. All orders for the Commission's publications should be sent to the same address. Inquiries relating to the work of the Commission should be addressed to me at 83 Fellows Road (Garden Flat), London, N.W.3.

International Commission on
Zoological Nomenclature,
Publications Office,
41 Queen's Gate,
London, S.W.7.

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THE REMARKABLE DISTRIBUTION OF AN AMERICAN CICADA; A NEW GENUS, AND OTHER CICADA NOTES[1]

BY WILLIAM T. DAVIS

STATEN ISLAND, N. Y.

QUESADA GIGAS, A REMARKABLE CICADA
(Plate VIII, Figs. 1, 2)

A number of species of North American cicadas occur from the Atlantic seaboard to about western Kansas, or to the one hundredth meridian, and northward from Florida and Southern Texas to Nova Scotia and the region of the Great Lakes. In Western North America, where there are a greater number of species than in the Eastern States and Canada, the species extend eastward to about the 100th meridian. Two species of *Okanagana*, namely *rimosa* and *canadensis*, in the northern part of their range, where they follow the belt of evergreen forest extending from Nova Scotia to the far west, have a greater east and west distribution than the cicadas occurring more to the south. In: "A Preliminary Review of the West Coast Cicadidæ," 1915, Mr. E. P. Van Duzee states regarding *rimosa:* "This species occurs across the whole continent from Vancouver Island to Quebec and as far south on the west coast as Fresno Co., California."

In Texas there are at least 40 species of cicadas and several additional named forms or varieties. The most famous species occurring in Texas, is *Quesada gigas* Olivier, remarkable on account of its distribution as well as its loud song, which has been

[1] I am indebted to Howard Cleaves for photographing the specimens.

likened by many observers to the shrill whistle of a first-rate locomotive. In: "The Naturalist on the River Amazons," Bates states: "Added to these noises were the songs of strange cicadas, one large kind perched high on the trees around our little haven setting up a most piercing chirrup; it began with the usual harsh jarring tone of its tribe, but this gradually and rapidly became shriller, until it ended in a long and loud note resembling the steam-whistle of a locomotive engine. Half-a-dozen of these wonderful performers made a considerable item in the evening concert. I had heard the same species before at Pará, but it was there very uncommon."

The common name for *gigas* in some localities is the: "Locomotive Cicada," and it is also called the: "Soupbug," because it is at times attracted to light in its evening flights and lands on the supper table.

It is the only known American cicada that may be found in the mature or winged form every month in the year in some part of its extensive north and south distribution of about 4,000 miles, from southern Texas through Mexico, Central America, South America into Argentina.

In the writer's collection there are many specimens from southern Texas, where it has thus far been recorded from May to October; there are many records from Mexico; also from Central America, and in South America specimens from Colombia, Venezuela, Trinidad, Tobago Island recorded in February and March; British Guiana in September (Dr. Beebe and John Tee-Van); Ecuador; Brazil in September, December, January, May; Peru in March, June, September, October; Bolivia in February; Paraguay in December and January. Specimens from Argentina are dated November and December, and it doubtless occurs at other dates.

In his: "Synopsis of the Cicadidæ of Ecuador," 1925, Dr. Frederic W. Goding states regarding the Genus *Quesada* that: "One species has been recognized in Ecuador, which is greenish yellow, with a fuscous spot on the bases of the second and third apical cells of tegmina; it is one of our largest species."

Dr. Kenneth J. Haywood, Chief of the Department of Entomology, Tucuman, Argentina, has informed me that *Quesada*

gigas, is, speaking generally, distributed over Argentina north of a line drawn between Buenos Aires and Mendoza. So far there are no available records for Chile or Uruguay. The Doctor states that this fine cicada is called: " 'Chichara grande' (chichara is a common name for the cicada here), 'Coyoyo,' or more commonly 'Coyuyo,' according to what part of this vast country you find yourself in."

Considering the extended distribution of the species, the specimens from the various parts of its wide range are surprisingly alike, but sometimes differ individually in color. Those from Brazil, Argentina, etc., are often quite large, with abdomen noticeably broad in the males, but Texas specimens may also differ considerably in size.

There is a colored figure of the insect under the name of *Tympanoterpes gigas* in "Biologia Centrali-Americana," 1881, with an interesting account of its song and habits. In: "Insect Singers, A Natural History of the Cicadas," Dr. J. G. Myers devotes considerable space to an account of this remarkable species, its song and habits.

In his: "Catalogue of the Cicadidæ," 1906, Mr. Distant cites a number of specific names that have been bestowed upon *Quesada gigas*, and when more specimens have been collected from the different parts of its remarkable range, and additional field studies have been made, including time of appearance, it may be discovered that there are some definite geographic races or even an additional species involved.

In his: "Preliminary Survey of the Cicadidæ of the United States, Antilles and Mexico," 1892, Uhler stated concerning *gigas*: "I have examined specimens from various parts of Mexico, and from Guatemala, Guiana, and Matto Grosso, Brazil. Specimens from Tamaulipas, Mexico, differ in no respect from others living further South, although the species is a very variable one especially in the amount and form of black marking on the upper surface of the body. The region of the Rio Grande of Texas is the most northern limit of this species, while the northern part of the Argentine Republic seems to be its most southern habitat."

In: "Notes Del Museo de la Plata," Tomo V, Buenos Aires, 1940, Prof. Belindo Adolfo Torres described and figured a dark-

colored female of *gigas*, but as he could find no structural difference he considered the variety unworthy of a name.

In Texas *Quesada gigas* has been recorded from Starr, Hidalgo, Cameron and Bexar counties by Mr. F. F. Bibby, and no doubt it will be discovered over a wider range. There are specimens from Kingsville, Kleberg County, in the collection of Cornell University.

Mr. H. B. Parks, Director of the State Agricultural Research Laboratory near San Antonio, Bexar County records *gigas* as a yearly visitor observed since 1934. The "Popcorn Whistlers" occur in the live-oaks about the Laboratory, usually in July and August, and he heard them singing in the evening and sometimes in the early morning in 1941. He has found dead specimens beneath the trees. He also reports their abundance in the coastal city of Corpus Christi, Nueces County, in August, 1940. The little boys in town found great sport in climbing trees and catching the cicadas. They had also been observed and collected in 1938 at Corpus Christi, and I received specimens from both Mr. Parks and Mr. Emmett S. Claunch, Jr., who reported that they: "whistle instead of buzz—that is they sound as though they whistle."

Many collectors have found *gigas* about Brownsville, Cameron County, and Dr. James A. G. Rehn, of the Philadelphia Academy, likened its song to the shrill tin whistle of a peanut roaster.

Dr. Raymond H. Beamer and associates from the University of Kansas collected in Bee County and Hidalgo County in July, 1928, and in sending specimens the Doctor wrote that they had 70 more if I cared to see them. This, as well as some of the other facts are mentioned to show what a highly successful species *gigas* really is, both in numbers as well as in wide distribution, for in some part of its range from north to south, a male *gigas* is in song every month in the year.

Mr. Paul C. Avery of Mission, Hidalgo County, near the Rio Grande, has sent me a great many *gigas*, which sometimes occurs very plentifully along the river where the soil is more or less damp. He has found them often on Mesquite, and describes the song as: "Very loud, continuous and shrill. The loudest of any species found," at Mission. He collected many in 1935, and in

1936 sent me as a sample 400 specimens—247 males and 153 females—collected in July of that year. He observed the first *gigas* on June 13, and in his letter of July 5, 1936, stated that they sang both early and late, and often were heard singing after dark. He heard the last one on September 21 in 1936. Mr. Avery has also observed the Cicada killer, *Sphecius*, with a *gigas*, which: "sure was crying loud and mournfully." This species like many other cicadas, is subject to a fungus disease, and a number of specimens have been received with the terminal segments of the abdomen missing, as often happens when the Seventeen-year Cicada is attacked by fungus.

It will be seen from the foregoing, that in *Quesada gigas* the United States includes in its fauna one of the most remarkable of the known cicadas, which species is sure to attract more and more attention in the years to come.

Cornuplura, new genus.

In the JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY for June, 1936, *Tibicen curvispinosa* was described and figured as a remarkable cicada from western Mexico. The two conspicuous upturned spines in the male protruding backward from segment IX, were described and figured, and it was stated that: "the uncus in *curvispinosa* is deeply cleft with the resulting two claw like extremities long and curved inward." These characters are also noted by Smith and Grossbeck in: "Studies in Certain Cicada Species," Entomological News, April, 1907, and shown in their figures 7 and 8 on plate 3.

Tibicen nigroalbata was also described in the 1936 paper, and its resemblance to *curvispinosa* noted. Only a single female *nigroalbata* taken by Prof. E. D. Ball in Arizona was available in 1936.

In the JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY for June, 1942, these remarkable cicadas are again considered in the light of additional specimens from Nayarit, Mexico, and Santa Cruz County, Arizona, and it was suggested that *nigroalbata* might be a northern race of the southern *curvispinosa*.

The general form of the body except for the curved spines in the males of both *curvispinosa* and *nigroalbata*, including the position of the cross-veins in the fore wings, and the terminal central spine on the last dorsal segment in the males, is as in the genus *Tibicen*, but the deeply cleft and curved uncus is not as found in the other species of that genus native to North America, nor as in *plebeja* Scopli, of Europe, the type of the genus. It is suggestive of the uncus in some species of *Diceroprocta*, but in that genus the dorsal segment in the male terminates in two lateral lobes and the venation is different.

It would appear from the above that a new genus should be erected for these remarkable insects with *curvispinosa* as a type, to be placed between *Tibicen* and *Diceroprocta*, for which the name *Cornuplura* is here proposed. The genus may also include *rudis* Walker, from Mexico, as a closely related species.

The student is referred to several of the structural characters illustrated in the above-mentioned three papers, as characteristic of the Genus *Cornuplura*.

OKANAGANA SYNODICA (SAY), ITS HABITS, DISTRIBUTION, AND A NEW COLOR FORM

In 1825 Thomas Say described his *Cicada synodica*, and stated that: "Dr. James and Mr. Peale observed this species in great numbers in one locality at the base of the Rocky Mountains but it did not occur elsewhere." He described the body as black above, and also enumerated the extensive testaceous colored lines and spots that generally give a number of the insects when seen together a yellow-brown appearance. Say states: "Scutel [mesonotum] with a lateral marginal line the elevated X and two dorsal dilated lines testaceous; the dorsal lines are merely emarginate on the inner side, and do not form the W; at the tip of each anterior line of the X is a conspicuous, black impressed puncture, and behind the X the posterior edge of the scutel [metanotum] is visible and testaceous: beneath very pale testaceous. . . . Length to the tip of the hemelytra less than one inch."

In the Kansas University Science Bulletin, March, 1920, p. 345, Dr. P. B. Lawson, in: "The Cicadidæ of Kansas," records *synodica* from the western part of the state only, and describes it as: "A small black and honey-yellow species," with length of body 15 to 18.5 millimeters, and expanse of fore-wings 38 to 44 mm.

Mr. Joseph Duncan Putnam in his: "Remarks on the Habits of Several Western Cicadæ," Pro. Davenport Academy of Natural Sciences, March, 1881, records that: "*Cicada synodica* Say, was quite common on the grassy plains near Denver and Boulder, in Colorado, in June, 1872. The male makes a tolerably loud rattling noise." In June, 1920, the late Dr. Lutz, of the American Museum of Natural History, collected four male *synodica* at Medicine Bow, Wyoming, about 6,600 feet; and recorded that: "The small brown cicada in grass has a continuous note, but sometimes continues for only a short time."

In June and July of 1935 a brood of this species appeared in Colfax County, New Mexico. In the writer's collection there are 135 specimens representing this brood, and they are all of the typical brownish-colored form.

In his account of: "Characteristics of Certain Western Cicadas," JOUR. N. Y. ENTO. SOC., June, 1940, Dr. John W. Sugden records that: "A large brood of *Okanagana synodica* was observed in Emery County, Utah (June 7, 1928). At first, the sound was mistaken for the humming of the carburetor of the car. In the field, so many were buzzing that it was impossible to locate the position of any individuals. After examining the low, sage-like bushes, thousands of the insects were found. Fifteen or twenty could be easily collected on a bush not over a foot high. The note similar to the typical *Okanagana* song, was not very loud, but shrill and long continued and what the individual lacked in volume was made up for by the large numbers. Very few would fly if disturbed, but would remain on the bushes and could be collected by hand. Others would become quiet when disturbed and fall to the ground, where their color closely resembled the buff-colored soil. Many were mating. The exuvia were on the ground or attached to the stems."

The known range of *synodica* has been greatly extended in recent years, and specimens have been examined from Alberta, Montana, North and South Dakota, Wyoming, Nebraska, western Kansas, Colorado, Utah, western Texas, New Mexico and Arizona. It should also be found in Oklahoma as some of the known localities are close to the state line. About 600 specimens have been examined, and it has been observed as the specimens accumulated that the broods appearing in Arizona and New Mexico were sometimes composed of darker-colored individuals than the broods occurring in Colorado and other more eastern localities.

On May 26, 1941, Mr. Frank H. Parker collected a great many almost entirely black-bodied individuals at Holbrook, Navajo County, eastern Arizona, and wrote as follows concerning them: "The Holbrook series was taken on a large, slightly rolling mesa covered chiefly with bunch grass, *Gutierrezia*, and a low (1 foot or less) shrub somewhat resembling Fairies Feather Duster, among which was to be found an occasional diminutive *Opuntia*.

The capacity of my cyanide jars, and time, were the only factors preventing the capture of many thousands of this species." Mr. Parker sent 67 males and 33 females from this brood.

In the writer's collection there are also two females of the dark form collected at Holbrook, May 22, 1934, and a male and female of the same form from the White Mountains, Arizona, July, 1935. Broods of both the light and dark forms occur in New Mexico, and both dark and light colored specimens have been received from Utah, collected by Dr. Sugden, June 7, 1928, in Emery County.

It will be noted that broods of the dark, or almost wholly black individuals, generally occur in the area drained by the Colorado, while those of the lighter-colored form described by Say, are on the more eastern watershed, or streams tributary to the Rio Grande, Missouri, etc.

Okanagana synodica (Say) variety **nigra**, new variety (Plate VIII, fig. 3). Type male and allotype female from Holbrook, Arizona, May 26, 1941 (Frank H. Parker). Davis collection.

In this dark or melanistic form of *synodica*, the testaceous markings as described by Say are absent or very much reduced. The head is entirely black save for two pale spots one above each antenna, and the ruby-colored ocelli. The pronotum is narrowly edged all around with orange, and has a short, median pale line extending to the anterior margin. The mesonotum has a very small orange spot at the base of each fore wing; the posterior margin, including the X, pale, and the two torch shaped orange marks, extending forward from the anterior limbs of the X generally lack the often conspicuous tooth like mark or sinuation on the inner side found in typical *synodica*. The metanotum is pale and the abdominal segments are black or very narrowly margined posteriorly with orange. In the female the segments at the end of the body are more broadly margined with orange. The upper surface of the uncus of the male is black, and the valve pale. The venation is darker than in typical *synodica*.

OKANAGANA PALLIDULA DAVIS; ADDITIONAL NOTES AND OBSERVATIONS

(PLATE VIII, FIG. 4)

In the JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY for September, 1938, there is an account of this species, its distribution and color forms, and the variety *nigra* is described and recorded from Yolo and Kern counties, California. *Pallidula* can be confused with some of the forms of *Okanagana vanduzeei*

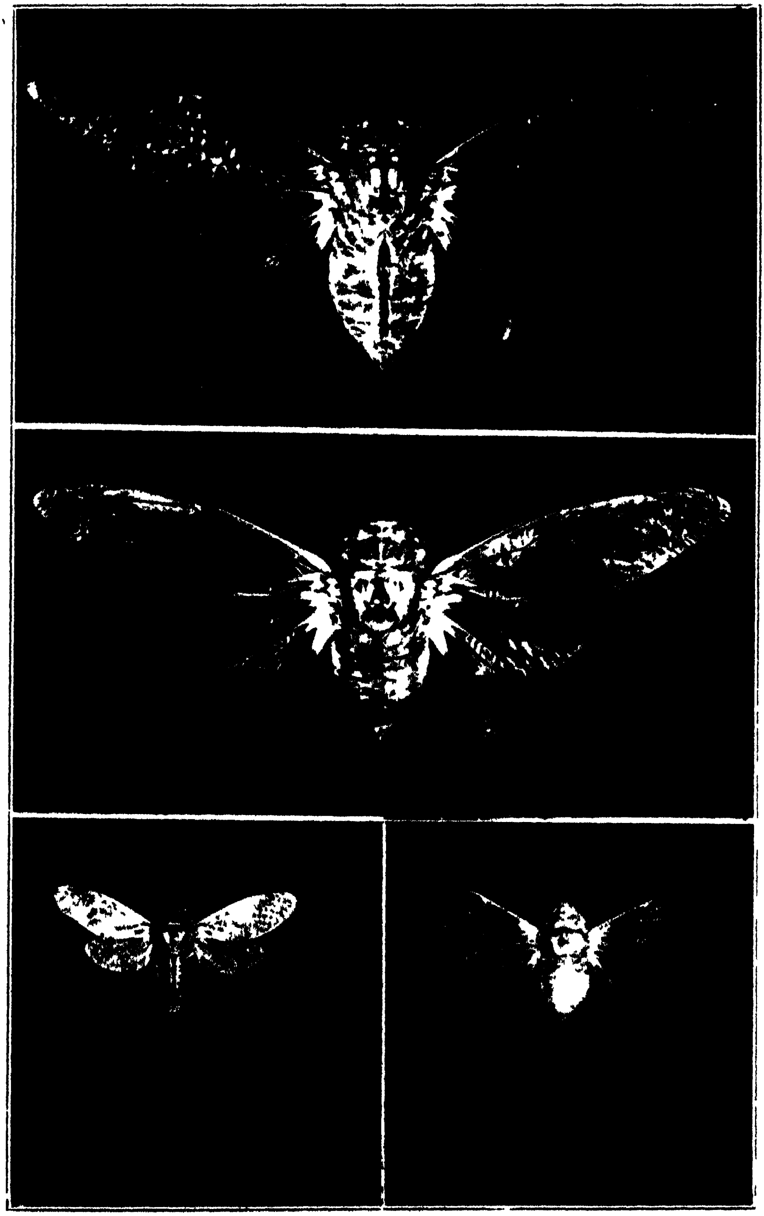
which, however, are usually conspicuously hairy on the head, and often on the pronotum, as well as on the under side of the abdomen. Also *pallidula* is duller and does not present the shining appearance usual in *vanduzeei* and its forms. While there are dark specimens of *pallidula* there are also green ones, which apparently do not occur in *vanduzeei* and its varieties *consobrina*, etc.

Okanagana pallidula has thus far been examined from the great Central Valley of California, and from the following counties: Sutter, Yuba, Yolo, Sacramento, Contra Costa, Merced, Madera, Fresno, Tulare, Kings, Kern and San Luis Obisbo. In some years it occurs in great numbers.

As reported on page 308 of the September, 1938, paper referred to above, this small cicada may be found singing from its hole in the ground. In June, 1941, Mr. and Mrs. J. N. Knull of the Ohio State University, while in the Santa Maria River Valley, California also found specimens of *pallidula* singing from their burrows where it was believed they had undergone their last transformation. If the males ultimately found mates, they probably in due time left the burrows, or perhaps the females flew to them as has been observed in other species. This is a matter for future observation and record. Dr. Charles D. Michener of the American Museum of Natural History, while looking over my collection of cicadas in 1942, assured me that he had discovered males of *pallidula* singing from their one-time burrows, thus adding to the observations made by others.

PLATE VIII

Figure 1. *Quesada gigas* (Olivier). Male from Texas.
Figure 2. *Quesada gigas* (Olivier). Female from Argentina.
Figure 3. *Okanagana synodica* (Say) variety *nigra*. Type.
Figure 4. *Okanagana pallidula* Davis.



EPHRAIM PORTER FELT

EPHRAIM PORTER FELT—1868–1943

The New York Entomological Society as well as the entire scientific world has lost one of its most respected and outstanding members in the passing of Dr. E. Porter Felt. He was a leader in the field of entomology and was recognized as such internationally. He was widely known as a scientist, writer and lecturer. As State Entomologist of New York for thirty years his valuable publications were looked upon as standard for this type of work. As Director of the Bartlett Tree Research Laboratories from 1928 until his death, he became a world authority on the care of shade trees. Real leaders are few in any walk of life. Dr. Felt was one of the few but his influence was valued by many.

Ephraim Porter Felt was born at Salem, Massachusetts, January 7, 1868, a son of Charles Wilson Felt and Martha Seeth (Ropes) Felt. His background was like one of many similar old New England families. As a youth he had decided upon the ministry as a career but became interested in insect problems while attending college and this became the basis of his life work. He received the degree of B.Sc. from the Massachusetts Agricultural College in 1891 and also a degree of B.Sc. from Boston University the same year. The degree of D.Sc. was bestowed upon him by Cornell University in 1894. After teaching Natural Science at The Clinton Liberal Institute, Fort Plain, New York, from 1893–1895, he became Assistant to the State Entomologist at Albany. Upon Dr. Lintner's death, he became State Entomologist of New York, which post he held for thirty years, until 1928 when he came to the Bartlett Tree Research Laboratories as Director and Chief Entomologist.

In the field of insect taxonomy he achieved international fame for his careful and extensive studies on the gall midges—the Cecidomyidæ or Itonididæ as he preferred to call them. In 1913 he gave the annual public address on Gall Insects before the Entomological Society of America at Atlanta, Georgia. In 1914 he was elected a member of the American National Committee on Nomenclature of the Second International Congress. I have learned from Professor C. P. Alexander of Massachusetts State

College that Dr. Felt had reported to him in 1942 that he had described 1,060 new species of gall midges and plant mites. With the late D. B. Young, his assistant at Albany, he had described a number of mosquitoes which are indicated in the literature under the joint authorship of Felt and Young.

Dr. Felt became a corresponding member of the New York Entomological Society on October 20, 1900, and an active member on February 5, 1907. After coming to Stamford in 1928 he frequently presented papers at the New York Entomological Society meetings which included subjects of a varied nature from gall midges to poetry concerning insects, as well as numerous valuable contributions on shade tree insects.

Dr. Felt's first entomological work was in Massachusetts in the early days of the gypsy moth invasion. His experience with this destructive forest and shade tree pest led him in 1924 in his work for the New York State Conservation Commission to propose a barrier zone two hundred miles in length to stem the spread of the gypsy moth into New York State from New England.

Dr. Felt was a pioneer in airplane collection of insects and made extensive studies on windborne insects. He made studies on the wind drift of insects on the top of the State Education Building, Albany, N. Y., the Empire State Building in New York City, as well as on other tall city buildings and his work on windborne insects has been very important in ascertaining the direction of spread of the Dutch elm disease which is carried to a large extent by the European elm bark beetle.

In the late 90's and early 1900's, Dr. Felt studied the spread of many diseases by the common house fly and by mosquitoes and made important contributions to this phase of entomology. In the February, 1944, issue of the National Geographic there was an article "Saboteur Mosquitoes" by Mr. Stage, Senior Entomologist of the United States Bureau of Entomology and Plant Quarantine, in which is recorded some of the work done on mosquitoes years ago under the direction of Dr. Felt.

Dr. Felt was very much interested in and very capable of doing editorial work and was editor of the Journal of Economic Entomology since its start in 1908. At one time he was editor of the National Shade Tree Conference Reports.

While State Entomologist of New York he published 25 official reports covering the activities of that office and many bulletins, which were published by the New York State Museum, as well as more than 700 timely papers and articles which included a wide variety of entomological work comprising general entomology as well as popular articles of an informative nature for the general public. He was a frequent contributor to entomological journals and scientific publications, as well as magazines and newspapers. He found time to give numerous addresses, to publish several popular books and to speak over the radio on different phases of entomological and shade tree activities. His published reports and bulletins were models of systematic arrangement and clarity of expression.

During his long and useful career, Dr Felt had been a collaborator of the United States Bureau of Entomology, the entomological editor of the Country Gentleman from 1898 to 1911 and a member of the Supervisory Board of the American Year Book. He was a past president of the American Association of Economic Entomologists, a past president of the National Shade Tree Conference, a fellow of the Entomological Society of America, a life member of the American Entomological Society, a member of the New York and Washington Entomological Societies and of Sigma Xi and Phi Kappa Phi. Among the honors accorded him were a gold, and three silver medals at the Pan-American Exposition, Buffalo, N. Y., in 1901. He was a member of the Fraternity of Alpha Sigma Phi.

For the last twelve years, he was the author of a weekly syndicated newspaper article entitled "Talks on Trees" which was used by nearly three hundred newspapers throughout the country. He was the author of a number of well-known books on insects and trees, his two-volume work "Insects Affecting Park and Woodland Trees" appearing in 1906 and "Manual of Tree and Shrub Insects" in 1923. He was co-author with Dr. W. H. Rankin of "Insects and Diseases of Ornamental Trees and Shrubs" published in 1932. His "Plant Galls and Gall Makers" appeared in 1940.

Three outstanding books on shade trees were published more recently—"Our Shade Trees," in 1938, a second edition of which

appeared in 1942; "Pruning Trees and Shrubs," in 1941, and "Shelter Trees in War and Peace," in 1943.

On December 8, 1943, Dr. Felt attended the national meetings of the American Association of Economic Entomologists held in Columbus, Ohio. On his way back he stopped at Utica, N. Y., to visit his son. He was back at his office on Monday, December 13. He seemed none the worse for the rigorous trip and was in excellent spirits. On Tuesday morning, December 14, he told his secretary that the night before he doubted whether he would be in that day. He said he felt as though he was coming down with the flu the night before but felt all right that morning. With a twinkle in his eye, he said that he had had such symptoms before and that nothing came of them. "You see," he said, "I am still pretty tough." These were the last words that Miss Burns, his secretary, heard him speak. I talked with him a few minutes later when he was going out to the Ferguson Library to look up some references and he seemed to be all right then. Later he came back to the building and died very suddenly of a heart attack.

Surviving him, in his immediate family, are three daughters and a son, a sister and two brothers, and thirteen grandchildren.

A few days after Dr. Felt had passed away, I received a letter from Dr. Peairs, present editor of the Journal of Economic Entomology, recounting his conversation with Dr. Felt during the Columbus meetings. I would like to quote that part of Dr. Peair's letter.

"I cannot refrain from telling you a little episode in Columbus; I had a chat with Dr. Felt and he brought up a discussion of some of the members who had recently died; I casually mentioned the fact that four ex-presidents had died in the last few months. Dr. Felt, with his faint smile, remarked, not seriously at all, 'I am hereby resigning my position as an ex-president of the Association, effective at once.' I am sure he thought of it as nothing but a little joke, as I did. But somehow, I almost wish the subject had not come up."

Dr. Felt was a great scientist, a splendid gentleman and an invaluable friend. Honest, sincere and upright, he moved through life with a tranquil demeanor and faith in his fellow

men. Trivialities neither upset him nor deterred him from any worthy purpose or goal.

His prime thoughts were for the younger, newer men. All were stimulated by his great personality. He aided their efforts with cheer and lent a helping hand no matter how adverse the difficulty or how uncertain the going.

I first met Dr. Felt in 1920. I have known him as a friend, as a counsellor, as a superior and as a leader. Since 1929, it was my privilege and honor to work with him side by side on important research and I have never ceased to marvel at his deft ability to size up and conquer a problem and at his unruffled composure in the face of trying obstacles.

Of him I can use no greater expression than to say that he was an all around great American. His flexibility of outlook was manifested by the ability to direct itself in a flash from the deep abstruse contemplation of science to the broad generalities of national life. He was intensely interested in the world about him. His human ties were broad and comprehensive. His love for children was apparent to many.

He was an avid reader, and enjoyed the radio from the political speeches of the great to the humor of Charlie McCarthy. He had a deep and abiding sense of humor and was quick and accurate at repartee. A remark was once made on his winged collar, so characteristic of his dress. Dr. Felt immediately replied "What could be more fitting to my profession?" pointing to the two-winged insects he was studying.

He was faithful to the minute to his commitments. Many were the occasions when he accepted an invitation to talk at some humble, out-of-the-way garden club or other meeting. If he said he would be there, he was always present. This custom alone stamped him as a man of his word in the eyes of many of his great circle of friends.

His appearance as well as his character was left unchanged by the surging tide of years and he was until the last the same steadfast, striking figure. His carefully trimmed, white hair and Van Dyke beard, his calm, upright bearing, his impeccable dress, his gentle but firm voice, all reflected the imprint of his great character.

How frequently and forcefully the realization has come to me during the past two months that we will never again experience together the exhilaration of solving an important problem, or of unravelling one of nature's intricacies again; that no more will we talk over together the problems of the present or the plans of the future; that no more will I have his steadfast character upon which to lean or his guiding hand to point the way!

While his passing has been such a personal loss to me, how much greater has been the loss to the profession of entomology and to the entire world of science. His contributions will loom in importance during the passing years even as the memory of his personality may dim and fade.

The accompanying bibliography, transcribed from the card index by his secretary, Miss Beatrice Burns, gives his publications in chronological order. It is an inescapable conclusion that such a bibliography cannot be complete. Dr. Felt was accredited with having written more than seven hundred important and timely papers and articles which include a wide variety of entomological works.

The following may be considered his outstanding writings:

BIBLIOGRAPHY OF DR. E. P. FELT

1893. *Nomophila noctuella.* Can. Ent. 25: 129.

1894. On certain grass-eating insects. Cornell Agric. Exp. Sta. Bull. 64.

1896. The scorpion flies. (10th Rep't) N. Y. State Ent. for 1894.

1901. Suggestions toward greater uniformity in nursery inspection laws and rulings. Conv. of the Assoc. of Amer. Agr. Colleges and Experiment Stations, Bul. No. 99.

1902. N. Y. State Mus. Bul. 53 (17th Rep't), 705–30, 741–44.

1902. Crude petroleum as an insecticide. Twenty-Third Meet. Soc. Prom. Agr. Sc. p. 1.

1903. Literature of American economic entomology. Bureau of Entomology Bul. 40, new series, 7–22.

1904. (With L. H. Joutel) Monograph of the genus *Saperda.* N. Y. State Mus. Bull. 74, 1–80.

1904. Importance of isolated rearings from culicid larvæ. Ent. Soc. Wash. Proc. VI, Vol. XX, 312–13.

1904. The mosquitoes or culicidæ of New York State. N. Y. State Mus. Bull. 79, 241–400, 113 fig., 57 pl.

1904. The cause and control of insect depredations. Twenty–Fifth Ann. Meet. Soc. for Promotion Agr. Sc., p. 73.

1905. *Cecidomyia hirtipes.* N. Y. State Mus. Bull. 97 (Rep't 1904), 410–11.
1906. Diversities among New York mosquitoes. Proc. 2nd Anti-Mosquito Conv. New York City, 1904.
1906. Mosquito control. N. Y. State Mus. Bull. 104 (21st Rep't), N. Y. State Ent., 1905.
1906. Studies in Cecidomyiidæ. N. Y. State Mus. Bull. 104 (21st Rep't, 1905), 116–32.
1906. Plant galls & gall makers. N. Y. State Mus. Memoir 8, 2: 615–48.
1906. Insects affecting park & woodland trees. N. Y. State Mus. Mem. 8, vol. 1, 1–332.
1907. Hort. diseases and pests. N. Y. State Ed. Dept. Rev. of Legislation, 119–22.
1907. New species of Cecidomyiidæ. N. Y. State Mus. Bull. 110, 97–165. Separate, 1–53. Lingnan Science Jour., Vol. 7., 469.
1907. Gall gnats or Cecidomyiidæ. Can. Ent., 39: 143–44.
1907. Cecidomyiidæ: A statement. Can. Ent., 39: 197–98.
1907. *Cecidomyia acarivora* n. sp. Ent. News, 17: 242.
1907. New species of Cecidomyiidæ II, p. 1–23 Same in N. Y. State Mus. Bull. 124, 286–304.
1908. *Cecidomyia johnsonii* Sling. Jour. Econ. Ent., 1: 243.
1908. *Contarinia gossypii* n. sp. Ent. News, 19: 210–11.
1908. Insect control in its larger aspects. Fruit Growers Proceedings, p. 1.
1908. Some problems in nomenclature. Ann. Ent. Soc. of America, p. 102.
1908. Observations on the genus *Contarinia.* Jour. Econ. Ent., 1: 225–28.
1908. Observations on the biology and food habits of the Cecidomyiidæ. Jour. Econ. Ent., 1: 18–21.
1908. Studies in Cecidomyiidæ II. N. Y. State Mus. Bull. 124 (23d Rep't), 286–304.
1908. New species of Cecidomyiidæ II. N. Y. State Mus. Bull. 124, 307–510.
1910. *Schizomyia ipomoeæ* n. sp. Ent. News, 21: 160–61.
1910. Gall midges of Aster, Carya, Quercus and Salix. Jour. Econ. Ent., 3: 347–56.
1910. West Indian Cecidomyiidae. Ent. News, 21: 268–70.
1910. Two new Cecidomyiidæ. Ent. News, 21: 10–12.
1910. Observations on the house fly. Jour. Econ. Ent., 3: 24–26.
1911. A generic synopsis of the Itonidæ. Jour. N. Y. Ent. Soc., 19: 31–62.
1911. Summary of food habits of American gall midges. Ann. Ent. Soc. America, 4: 55–62.
1911. *Endaphis* Kieff., in the Americas (Dipt.). Ent. News, 22: 128–29.
1911. *Endaphis hirta* n. sp. (Dipt.). Ent. News, 22: 224.
1911. Two new gall midges. Can. Ent., 43: 194–96, June.
1911. Four new gall midges (Dipt.). Ent. News, 22: 301–5.
1911. Hosts and galls of American gall midges. Jour. Econ. Ent., 4: 451–75.
1911. New species of gall midges. Jour. Econ. Ent., 4: 476–84; 546–59.
1911. *Miastor americana* Felt, an account of pedogenesis, N. Y. State Mus. Bull. 147 (26th Rep't), 82–104.

1911. A new species of *Lasioptera* with observations on certain homologies. Psyche, 18: 84–86.
1911. New Indian gall midges. Mem. Dept. Agr. India Ent. Ser. VII, No. 4, 23–28.
1911. A new *Lestodiplosis*. Ent. News, 22: 10–11.
1911. Two new gall midges (Dipt.) Ent. News, 22: 109–11.
1911. Three new gall midges. Jour. N. Y. Ent. Soc., 19: 190–3.
1911. *Rhopalomyia grossulariæ*. Jour. Econ. Ent., 4: 347.
1912. New W. Indian gall midges (Dipt.). Ent. News, 23: 173–7.
1912. Observations on *Ulcella* Rubs. (Dipt.). Ent. News, 23: 353–54.
1912. *Lasiopteryx manihot* n. sp. Can. Ent. 44: 144.
1912. Studies in Itonididæ. Jour. N. Y. Ent. Soc., 20: 236–48.
1912. Observations on the identity of the wheat midge. Jour. Econ. Ent., 5: 286–89.
1912. The gall midge fauna of western North America. Pomona Coll. Jour. Ent., 4: 753–57.
1912. The identity of the better known midge galls. Ottawa Nat., 25: 65–67, 181–88; separate, 1–11.
1912. Biology of Miastor and Oligarces. Science, 33: 278–80.
1912. *Diarthronomyia californica* n. sp. Pomona Coll. Jour. of Ent., 4: 752.
1912. Petroleum & petroleum products as insecticides. N. Y. State Ed. Dept., Sc. Div. 2 p.
1912. *Itonida inopis*. Jour. Econ. Ent., 5: 368–69.
1912. Control of insect pests in institutions. Jour. of Home Econ., Vol. IV, No. 1, 16–26.
1912. New Itonidæ. Jour. N. Y. Ent. Soc., 20: 102–7.
1912. New gall midges or Itonidæ (Dipt.). Jour. N. Y. Ent. Soc., 20: 102–7.
1912. New gall midges or Itonidæ (Dipt.). Jour. N. Y. Ent. Soc., 20: 146–56.
1912. *Arthrocnodax occidentalis*. Jour. Econ. Ent., 5: 402.
1912. Observations on the identity of the wheat midge. Jour. Econ. Ent. 5: 286–9.
1913. *Cystodiplosis eugeniæ* n. sp. Ent. News, 24: 175–76.
1913. Adaptation in the gall midges. Can. Ent. 45: 371–79; also Ent. Soc. Ontario (44 Rep't), 1913, 1914, 76–82.
1913. The gall midge fauna of New England. Psyche, 20: 133–47.
1913. A study of gall midges. N. Y. State Mus. Bull. 165 (28th Rep't), State Ent., p. 127–227.
1913. Three new gall midges (Dipt.). Can. Ent. 45: 304–8.
1913. A study of gall midges. N. Y. State Mus. Bull. 175 (29th Rep't), 79–214.
1913. Gall midges in an aquatic or semiaquatic environment. Jour. N. Y. Ent. Soc., 21: 62–63.
1913. Table of hickory leaf midge galls. Bul. Bklyn. Ent. Soc., 8: 98–99.
1913. Two new Canadian gall midges. Can. Ent., 40: 417–18.
1913. *Didactylomyia capitata* n. sp. Psyche, 20: 174.

1913. Descriptions of gall midges (Dipt.). Jour. N. Y. Ent. Soc., 21: 213–19.
1913. *Itonida anthici* n. sp. Jour. Econ. Ent., 6: 278–79.
1913. Gouty pine midge. Jour. Econ. Ent., 6: 278–79.
1913. The goldenrod and its gall flies. Guide to Nature, 6: 149–51.
1913. *Arthrocnodax carolina.* Jour. Econ. Ent., 6: 488–89.
1914. Cecidomyiidæ by J. J. Kieffer. Fasc. 152 in Genera Insectorum. Ent. News, 25: 185–88.
1914. Additions to the gall midge fauna of New England. Psyche, 20: 109–14.
1914. *Acaroletes pseudococci.* Jour. Econ. Ent., 7: 148–49.
1914. *Diadiplosis coccidivora.* Entomologist, 47: 86.
1914. *Aplonyx sarcobati* n. sp. Pomona Jour. Ent. & Zool., 6: 93–94.
1914. Gall midges as forest insects. Ottawa Nat., 28: 76–79.
1914. List of zoophagous Itonididæ. Jour. Econ. Ent., 7: 458–59.
1914. Cactus midge, *Itonida opuntiæ.* Prickly Pear Trav. Comm. Rep't, 77–78.
1914. Notes on forest insects. Jour. Econ. Ent., 7: 373–75.
1914. Additions to the gall midge fauna of New England. Psyche, 20: 109–14.
1914. Descriptions of gall midges. Jour. N. Y. Ent. Soc., 22: 124–34.
1914. New gall midges (Itonidæ). Insec. Inscit. Menstr., 2: 117–23.
1914. *Hormomyia bulla* n. sp. Can. Ent., 46: 286–87.
1914. Conical grape gall *Cecidomyia viticola.* Jour. Econ. Ent., 7: 339.
1914. *Arthrocnodax constricta.* Jour. Econ. Ent., 7: 481.
1915. New genera and species of gall midges. U. S. Nat. Mus. Proc., 48: 195–211.
1915. New South American gall midges. Psyche, 22: No. 5.
1915. The gall midges of the pine. Bull. Bklyn. Ent. Soc., 10: 74–76.
1915. A study of gall midges II. N. Y. State Mus. Bull. 175 (29th Rep't), 79–213.
1915. A study of gall midges III. N. Y. State Mus. Bull. 180 (30th Rep't), 127–289.
1915. New Asian gall midges. Jour. N. Y. Ent. Soc., 23: 73–84.
1915. Fumigation for the box leaf miner. Jour. Econ. Ent., 8: 94–95.
1915. *Mycodiplosis macregori* n. sp. Jour. Econ. Ent., 8: 149.
1915. A new chrysanthemum pest. Am. Florist, 44: 162.
1915. New North American gall midges. Can. Ent. 47: 236–42.
1915. New gall midges. Jour. Econ. Ent., 8: 405–9.
1916. A study of gall midges III. N. Y. State Mus. Bull. 180 (30th Rept 't), 127–288.
1916. A study of gall midges IV. N. Y. State Mus. Bull. 186 (31st Rep 't), 101–73.
1916. New western gall midges. Jour. N. Y. Ent. Soc., 24: 175–96.
1916. Gall midges of certain Chenopodiaceæ (Dipt.). Ent. News, 27: 201–3.
1916. New North American gall midges. Ent. News, 17: 412–17.

1916. New Indian gall midges. Can. Ent., 48: 400–6.
1916. Distribution of gall midges. Natl. Acad. Sci. Proc., 3: 349–54.
1916. New gall midges. Can. Ent., 48: 29–34.
1916. *Lasioptera fructuaria.* Maine Agr. Expt. Sta. Bull. 244, 268–69.
1916. American insect galls. Ottawa Nat. 30: 37–39.
1917. Indian gall midges (Cecidomyiidæ, Dipt.). Ent. News, 28: 73–76.
1917. Entomological research and utility. Scientific Monthly, p. 551.
1917. New gall midges. Jour. N. Y. Ent. Soc., 25: 193–96.
1917. Distribution of gall midges. Natl. Acad. Sci. Proc., 3: 349–54.
1917. Little known gall midges of certain composites. Ottawa Nat., 31: 13–14.
1917. *Asphondylia websteri* n. sp. Jour. Econ. Ent., 10: 562.
1918. A study of gall midges V. N. Y. State Mus. Bull. 198 (32d Rep't), 101–252.
1918. Notes and descriptions of Itonididæ in the collections of the American Mus. of Natural History. Am. Mus. Nat. Hist., 38 (Oct. 6): 179–82.
1918. Gall insects and their relation to plants. Sci. Mon., 6: 509–25.
1918. New Philippine gall midges, with a key to the Itonididæ. Phil. Jour. Sci., 13: 281–325.
1918. Key to American insect galls. N. Y. State Mus. Bull. 200, 1–310.
1918. A study of gall midges VI. N. Y. State Mus. Bull. 202 (33d Rep't), 76–205.
1918. New gall midges. Jour. Econ. Ent., 11: 380–84.
1919. Five non-gall making midges. Ent. News, 30: 219–23.
1919. New Philippine gall midges. Jour. Sci., 14: 287–94.
1919. The plant galls collected by the Canadian Arctic Expedition 1913–18. Rept. Can. Arctic Exped., V. 3.
1919. Insect galls & gall insects. Ottawa Nat., 32: 127–31.
1919. The European corn borer. Cornell Ext. Bull. 31, 35–48.
1920. The European corn borer problem. Jour. Econ. Ent., 13: 59–74.
1920. Memoirs Department of Agriculture in India. Vol. VII—No. 1, for Imperial Department of Agr. in India.
1920. Four new African gall midges. Annals Natl. Mus., Vol. IV (part 2), p. 491–96.
1920. New Indian gall midges. Mem. Dept. Agr. India. Ent. Ser. VII, No. 1, p. 1–11.
1920. New Philippine gall midges. Phil. Jour. Sci., 17: 231–34.
1921. Three new sub-tropical gall midges (Itonidæ Dipt.). Ent. News, 22: 141–43.
1921. Observations on *Johnsonomyia* Felt with a description of a new species. Can. Ent., 53: 96.
1921. New species of reared gall midges (Itonididæ). Jour. N. Y. Ent. Soc., 29: No. 2, 165.
1921. A study of gall midges VII. N. Y. State Mus. Bull. (34th Rep't), 81–241.

1921. Adaptations among insects of field and forest. Scientific Monthly, 13: No. 2, 165.
1921. *Lasioptera apocyni*, new species (Diptera). Can. Ent., 53: 149.
1921. New Javanese gall midges. Extrait De Treubia, Vol. II, p. 89–92.
1921. The number of antennal segments in gall midges and a new species. Bull. Bklyn. Ent. Soc., 16: 93–95.
1921. Indian grass gall midges. Mem. Dept. Agr. India, Pusa Ent. Ser. VI, No. 3, p. 15–22.
1921. Javanese gall midges, Treubia, 1: 139–51.
1921. A new Javanese gall midge. Treubia, 1: 270–71.
1922. A new Diadiplosis. Zoologica, Vol. III, No. 8.
1922. The possibilities of exterminating insects. Scientific Monthly, 15: No. 1, 35–41.
1922. A new and remarkable fig midge. The Ent. (Summer Number), p. 5–6.
1922. New cecidomyiid parasite of the whitefly. U. S. Natl. Mus. Proc., 61: 1–2.
1924. Manual of tree & shrub insects. The Macmillan Co., N. Y., 382 p.
1925. School guide to insects and about insects. Univ. of State of N. Y. Press.
1925. Key to gall midges. (A Resume of Studies I–VII, Itonididæ). N. Y. State Mus. Bull. No. 257, 1–239.
1925. Dispersal of butterflies and other insects. Nature, p. 1.
1925. Insects and human welfare. Scientific Monthly, 21: 649–53.
1926. A new spruce gall midge (Itonididæ). Can. Ent., 58: 229.
1926. New non-gall making Itonididæ (Dipt.). Can. Ent., 58: 265–66.
1926. New species of Indian gall midges (Itonididæ). Memoirs of the Dept. of Agr. in India, 9: 241–45.
1927. Four new Indian gall midges. Mem. Dept. Agr. India, 10: 1–4.
1927. New species of East Indian gall midges. Treubia, 9: 385–89.
1928. A new African gall midge. Jour. N. Y. Ent. Soc., 36: (2), 123–24.
1929. The need for investigations on shade tree insects. Jour. Econ. Ent., 22: No. 2, 417.
1929. Hickory leaf gall midges *Caryomyia* species. Jour. Econ. Ent., 22: 422.
1929. Gall midges or gall gnats of the Orient (Itonidæ or Cecidomyidæ) Lingnan Sc. Jour., Vol. 7, 413–74.
1930. The Norway maple *Nepticula* (Lepidoptera). Proc. Ent. Soc. Wash., 32: 8, 146–9.
1930. Economic importance of shade tree insects. Jour. Econ. Ent., 23: 1, 109–13.
1930. (With S. W. Bromley) Shade tree problems. Proc. of the Ann. Meeting of the Natl. Shade Tree Conf., p. 13.
1930. Scientific names. Science, 21: No. 1834, 215–17.
1931. (With S. W. Bromley) Developing resistance or tolerance to insect attack. Jour. Econ. Ent., 24: 437.

1931. (With S. W. Bromley) Insecticide investigations during 1930. Jour. Econ. Ent., 24: 232.
1931. The effect of certain important insects on trees. Natl. Shade Tree Conf., 66–73.
1931. (With S. W. Bromley) Observations on shade tree insects. Jour. Econ. Ent., 24: 157–62.
1931. (With S. W. Bromley) Tests with nicotine activators. Jour. Econ. Ent., 24: 105.
1932. (With W. Howard Rankin) Insects and diseases of ornamental trees and shrubs. The Macmillan Co., N. Y., 507 p.
1932. A new citrus cambium miner from Puerto Rico. Jour. Dept. of Agr. of Puerto Rico, Vol. XVI, No. 2, 117–18.
1932. A new predaceous gall midge for California. Pan-Pacific Ent., 8: No. 4, 167–68.
1932. A new Japanese gall midge. Bull. Bklyn. Ent. Soc., 27: No. 2, 124.
1932. Tree insurance. Proc. Ann. Meet. Natl. Shade Tree Conf., p. 15.
1932. Shade tree insects. Proc. Ann. Meet. Natl. Shade Tree Conf., p. 77.
1932. Shade trees threatened by insect pests. Scientific Monthly, 35: 59–62.
1932. (With S. W. Bromley) Insecticides on shade trees and ornamentals. Jour. Econ. Ent., 25: 298.
1932. (With S. W. Bromley) Observations on shade tree insects. Jour. Econ. Ent., 25: 39.
1933. A hibiscus bud midge new to Hawaii. Proc. Haw. Ent. Soc., VIII, No. 2, 247–48.
1933. A new enemy of the pineapple mealybug and a list of gall midge enemies of mealybugs. Jour. N. Y. Ent. Soc., 41: Mar.–June, 187–89.
1934. New gall midges. Bull. Bklyn. Ent. Soc., 29: No. 2, 77–78.
1934. Fundamentals in the control of insect pests. Proc. 10th Natl. Shade Tree Conf., 37–43.
1934. Classifying symbols for insects. Jour. N. Y. Ent. Soc., 42: 373–92.
1934. A new gall midge on fig. (Dipt.: Itonididæ). Ent. News, 45: 131–33.
1934. Shade tree insects in 1933. Jour. Econ. Ent., 27: 195.
1935. Bark beetles and the Dutch elm disease. Jour. Econ. Ent., 28: No. 1, 231.
1935. (With K. F. Chamberlain) Occurrence of insects at some height in air, especially on the roofs of high buildings. N. Y. State Mus. Circ. 17, 70 p.
1935. *Trisopsis* in the United States (Dipt.: Itonididæ or Cecidomyiidæ), Ent. News, 46: 75.
1935. A new melon gall midge. Bull. Bklyn. Ent. Soc., 30: No. 2, 79–80.
1935. A new gall midge. Jour. N. Y. Ent. Soc., 43: 47.
1935. A gall midge on pine cones. Jour. N. Y. Ent. Soc., 43: 48.
1935. Bark beetles and the Dutch elm disease. Jour. Econ. Ent., 28: 231.
1935. The importance of shade tree insects in 1934. Jour. Econ. Ent., 28: 390.

1936. New midges on pine and grass. Jour. N. Y. Ent. Soc., 44: 7.

1936. (With S. W. Bromley) Oil effects on shade trees. Jour. Econ. Ent., 29: (2), 357–60.

1936. Two new cockle burr midges (Dipt.: Cecidomyiidæ). Ent. News, 47: 231.

1936. (With S. W. Bromley) Shade tree insect developments. Jour. Econ. Ent. 29: 490.

1936. The biology of mayflies, with a systematic account of North American species. Jour. Econ. Ent., 29: 223.

1936. Forest insects. Jour. Econ. Ent., 29: 1031.

1937. (With S. W. Bromley) Observations on shade tree insects and their control. Jour. Econ. Ent., 30: (1), 71–75.

1937. Dissemination of insects by air currents. Jour. Econ. Ent., 30: 458.

1938. A note on *Lasioptera murtfeldtiana* Felt. Jour. N. Y. Ent. Soc., 46: 44.

1938. (With S. W. Bromley) Shade tree insects and sprays, 1937. Jour. Econ. Ent., 31: No. 2, 173–6.

1938 Why do insects become pests? Scientific Monthly, 46: 437–40.

1938. A new species of gall midge predaceous on mealybugs. Proc. Haw. Ent. Soc., No. 1.

1938. Wind drift & dissemination of insects. Excerpt, Can. Ent., 221.

1938. Our shade trees. Orange Judd Publishing Company, N. Y., 187 p.

1939. (With S. W. Bromley) Hurricane of Sept. 21, 1938. Scientific Tree Topics No. 1, 1939, Vol. 1.

1939. A new juniper midge (Diptera: Cecidomyiidæ). Ent. News, 50: 159–60.

1939. A new gall midge on rhododendron. Jour. N. Y. Ent. Soc., 47: 41–42.

1940. (With S. W. Bromley) New insecticides and spreaders on shade trees. Jour. Econ. Ent., 33: 244–49.

1940. Rhododendron midge. Scientific Tree Topics 4, Vol. 1, p. 30.

1940. Insecticides and their use. Scientific Tree Topics 4, Vol. 1, p. 26.

1940. European elm bark beetle and Dutch elm disease control. Jour. Econ. Ent., 33: (3), 556.

1940. Danger to trees in an oversupply of quickly available nitrogen. Scientific Tree Topics 2, Vol. 1, p. 10.

1940. Pine root weevil. Scientific Tree Topics 2, Vol. 1, p. 13.

1940. Factors affecting Dutch elm disease spread. Scientific Tree Topics 3, Vol. 1. p. 18.

1940. Training trees for beauty. Scientific Tree Topics 5, Vol. 1, p. 34.

1941. (With S. W. Bromley) New and unusual shade tree pests. Jour. Econ. Ent., 34: (3), 383.

1941. With S. W. Bromley) Major shade tree insects, 1940. Jour. Econ. Ent., 34: (2), 180.

1941. The minute gall insect of white oaks. Scientific Tree Topics 7, Vol. 1, p. 55.

1941. Weather and winter drying. Scientific Tree Topics 7, Vol. 1, p. 50.

1941. Pruning trees and shrubs. Orange Judd Pub. Co., Inc., N. Y., 237 p.
1942. (With S. W. Bromley) The increasing importance of Coleopterous borers in shade trees. Jour. Econ. Ent., 35: (2), 169.
1942. Our shade trees. Revised edition. Orange Judd Pub. Co., Inc., N. Y., 316 p.
1943. How may the arboricultural profession serve a nation at war? 18th Natl. Shade Tree Conf., p. 29.
1943. Dutch elm disease control. Scientific Tree Topics 8, Vol. 1, p. 58.
1943. Shelter trees in war and peace. Orange Judd Pub. Co., N. Y., 320 p.

STANLEY W. BROMLEY.

NOTES ON MEXICAN BUTTERFLIES, III, DANAIDÆ

BY F. MARTIN BROWN

Danainæ

124. **Anosia berenice** Cramer.

G. & S. (1), **1**: 3; **2**: 638.
Ha. (2), p. 114, pl. 31a.
Ho. (5), p. 662.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 4 ♂♂ 1 ♀ vi. 16–18. 40 (H.H.).
Galeana, Nuevo Leon, 6500 ft., 2 ♂♂ 2 ♀♀ vii.29–viii.-1.39 (H.H.).
nr. Villagran, Tamaulipas, 1160 ft., 1♀ iv.28.41 (R.P.).
Hda. Sta. Engracia, Tamaulipas, 1 ♀ vii.27.39 (H.H.).
60 mi. So. of Victoria, Tamaulipas, 1 ♂ vii.5.36 (H.D.T.).
Jacala, Hidalgo, 4500 ft., 4 ♂♂ 6 ♀♀ vi.25–vii.3.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♀♀ v.28–29.41 (R.P.).
El Pujal, San Luis Potosi, 100 ft., 1 ♂ vii.20.39 (H.H.).
nr. Chilpancingo, Guerrero, 1 ♀ vi.26.41 (R.P.).
El Sabino, nr. Uruapan, Michoacan, 5 ♂♂ 1 ♀ vii.16–30.36 (H.D.T.).
Chichen Itza, Yucatan, 1 ♂ viii.30.36 (H.D.T.).

All this material is probably referable to race *strigosa* Bates. A few of the specimens (Villagran, Galeana, Jacala) have the greyish scales along the nervules of the upper side of the hind wings so reduced in number as to be difficult to see. There is some difference in ground color which I am inclined to believe is related to the freshness of the specimens. Those that are freshly emerged are brighter fulvous than those that have flown for some time which are rather dull dilute reddish brown. There is considerable variation in the development of the white spots in the dark margin of the hind wings. In two cases (a Jacala ♀ and an El Sol ♀) these spots are absent, in all of the others the outer row

is at least indicated and in some the second row is almost complete. The baso-apical radius of the fore wing varies from 31 to 47 mm. in the males and from 29 to 44 mm. among the females. There may be a tendency for the more northern specimens to be brighter and larger, and more clearly *strigosa*.

125. **Anosia cleothera** Godart.

G. & S., **1**: 3; **2**: 638.
Ha., p. 114, pl. 31b.
Ho., p. 663.
Galeana, Nuevo Leon, 6500 ft., 1 ♂ viii.1.39 (H.H.).
60 mi. So. of Victoria, Tamaulipas, 1 ♂ vii.6.36 (H.D.T.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♀ v.29.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 1 ♀ v.6.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.)

The Galeana record is rather far north for this species; however, it has been taken in Texas. In McDunnough's check list it is termed *eresimus* Cramer. I am not sure that *cleothera* is really valid for the Central American material, it was described from "Timor" (!) and the original description does not apply too well to our material. Cramer's species from the Guianas fits it no better so until a specialist settles the question it is best to let *cleothera* stand.

126. **Danaus plexippus** Linnæus.

G. & S., **1**: 1; **2**: 638.
Ha., p. 113 (as *archippus* F.), Vol. 1, pl. 28e.
Ho., p. 663 (as *curassavicæ* F.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♀ v.29.41 (R.P.).
Tancitaro, Michoacan, 6600 ft., 1 ♂ 2 ♀♀ vii.30–viii.11.40 (H.H.).

The El Sol specimen and one of the Tancitaro females are f. *fumosa* Hulst. Hoffmann lists this species as *Diogas curassavicæ* Fabricius. Apparently he overlooked Riley's paper (Tr. Ent. Soc. Lond., **76**: 451. 1929) which definitely linked the Linnean name with our "Monarch."

Ithomiinæ

My specimens of this subfamily were determined by R. M. Fox, of the Reading Public Museum. These represent six species of which Fox says, "All are common members of the Mexican tropical fauna." All of them were collected by Robert Potts. Of these six species five are among the twenty-eight Ithomiinæ in Hoffmann's list. The other has probably been confused by Hoffmann with *Ithomia patilla* Hewitson. I am following Hoffmann's order in this listing.

139. **Dircenna klugii** Hübner.

G. & S., **1**: 28; **2**: 644.
Ha., p. 138, pl. 36e.
Ho., p. 664.
Tuxpango, Vera Cruz, 1500 ft., 1 ♂ v.8.41.
Fortin, Vera Cruz, 1600 ft., 1 ♀ v.3–4.41.
Orizaba, Vera Cruz, 2000 ft., 1 ♀ v.6.41.

141A. **Ithomia hippocrenis** Bates.

G. & S., **1**: 51, pl. 5, f. 5.
Ha., p. 142.
Ho., p. 665 (*I. patilla* in part).
Ojo de Agua, Vera Cruz, 1600 ft., 3 ♂♂ 3 ♀♀ v.12.41.

A pair of these are deposited at the Reading Public Museum. This species is not listed by Hoffmann.

145. **Oleria paula** Weymer.

G. & S., **2**: 645 (*L. victoria* **1**: 38 in part).
Ha., p. 150.
Ho., p. 665.
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ 1 ♀ v.12.41.

Hoffmann *et al.* use the genus *Leucothryis* for this species.

149. **Pteronymia cotytto** Guérin.

G. & S., **1**: 44; **2**: 647.
Ha., p. 155, pl. 40c.
Ho., p. 665.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 3 ♀♀ v.28–29.41.

Tuxpango, Vera Cruz, 1500 ft., 1 ♀ v.8.41.

Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ 2 ♀♀ v.12.41.

A female from El Sol and one from Ojo de Agua are deposited at the Reading Public Museum.

153. **Greta oto,** Hewitson.

G. & S., **1**: 56; **2**: 648.

Ha., p. 164, pl. 41e.

Ho., p. 666.

Ojo de Agua, Vera Cruz, 1600 ft., 2 ♂♂ 3 ♀♀ v.12.41.

Hoffmann *et al.* place this and the following species in *Hymenitis*. A pair of *oto* is deposited at the Reading Public Museum.

154. **Greta nero** Hewitson.

G. & S., **1**: 57; **2**: 648.

Ha., p. 163, pl. 41e.

Ho., p. 666.

Fortin, Vera Cruz, 1600 ft., 1 ♂ v.3.41.

SATYRIDÆ

As is so frequent with collections made by inexperienced collectors in the tropics the catch of Satyridæ brought back by both Hoogstraal and Potts is small in comparison with what it might have been. The bulk of the specimens taken are *Euptychia.* Most of the jungle-loving species were not captured.

159. **Tisiphone maculata** Hopffer.

G. & S., **1**: 72, 651.

W. (3), p. 184, pl. 44b.

Ho., p. 666.

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♂♂ 1 ♀ v.28–29.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♀♀ vi.26–28.40 (H.H.).

The El Sol female is fresh; all of the other specimens are worn.

163. **Taygetis virgilia** Cramer.

G. & S., **1**: 97, 659.

W., p. 187, pl. 45a.

Ho., p. 666.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♂♂ v.28–29.41 (R.P.).

167. **Taygetis inconspicua** Draudt.
Ho., p. 667.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 7 ♂♂ iv.30, vi.28–29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♂ vi.28.40 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 2 ♂♂ vi.17–18.39 (H.H.).

The El Bañito male and several of the May specimens from El Sol are worn; the others are reasonably fresh. I suspect that this is nothing more than a form of *virgilia*. The genus will be treated in monographic form as a member of my series of papers devoted to Ecuadorian butterflies

172. **Neonympha gemma** Hübner.
G. & S., **1**: 92, 657, pl. 8, f. 12.
W., p. 223 (as *cornelius* F.), pl. 49f.
Ho., p. 667.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 2 ♂♂ 1 ♀ vi.18–20.40 (H.H.).
60 mi. So. of Victoria, Tamaulipas, 2 ♂♂ vii.6.36 (H.D.T.).
Jacala, Hidalgo, 4500 ft., 3 ♂♂ vi.24–29.39 (H.H.).
Fortin, Vera Cruz, 1600 ft., 1 ♂ v.4.41 (R.P.).

179. **Megisto hesione** Sulzer.
G. & S., **1**: 75, 651 (as *ocirrhoe*).
W., p. 194, pl. 46d.
Ho., p. 667.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 7 ♂♂ iv.30–31, v.28–29.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 2 ♀♀ v.12.41 (R.P.).

181. **Megisto mollina** Hewitson.
G. & S., **1**: 76, 652, pl. 8, ff. 13, 14 (fig. as *westwoodi*).

W., p. 195, pl. 46e.
Ho., p. 668.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 5 ♂♂ v.28–29.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 3 ♂♂ 3 ♀♀ v.12.41 (R.P.).

The females and one male from Ojo de Agua are f. *westwoodi* Butler.

182. **Megisto fetna** Butler.

G. & S., **1**: 77, 652, pl. 8, ff. 15, 16.
W., p. 195.
Ho., p. 668.
Chilpancingo, Guerrero, 1 ♂ vi.26.41 (R.P.).

184. **Megisto terrestris** Butler.

G. & S., **1**: 79.
W., p. 200.
Ho., p. 668.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 1 ♂ vi.19.40 (H.H.).

This specimen is probably not true *terrestris* which hails from eastern South America but may be the same form regarded as *terrestris* by Hoffmann. It is far north of Hoffmann's record "Selva virgen de Campeche (Tierra caliente)." It compares well with Weymer's figure noted above.

188. **Megisto rubricata** Edwards.

G. & S., **1**: 82, 655, pl. 8, f. 5.
W., p. 202.
Ho., p. 668.
Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 1000 ft., 1 ♂ vi.14.40 (H.H.).
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1600 ft., 1 ♂ vi.19.40 (H.H.).
Jacala, Hidalgo, 4500–5100 ft., 3 ♂♂ 2 ♀♀ vi.24.39 (H.H.).

190. **Megisto renata disaffecta** Butler.

G. & S., **1**: 82, 655, pl. 8, f. 5 (as *renata*).

W., p. 204, pl. 47d.

Ho., p. 668.

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ 1 ♀ iv.30–31.41 (R.P.).

Fortin, Vera Cruz, 1600 ft., 1 ♂ v.3.41 (R.P.).

Tuxpango, Vera Cruz, 1500 ft., 1 ♂ v.9.41 (R.P.).

Ojo de Agua, Vera Cruz, 1600 ft., 3 ♂♂ v.12.41 (R.P.).

El Sabino, nr. Uruapan, Michoacan, 1 ♂ 1 ♀ vii.15–30.36 (H.D.T.).

Chichen Itza, Yucatan, 2 ♂♂ viii.30.36 (H.D.T.).

Determination tentative.

191. **Megisto hermes** Fabricius.

G. & S., **1**: 86, 656, pl. 8, ff. 6, 7 (as *camerta*).

W., p. 207, pl. 48a.

Ho., p. 668.

Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1600 ft., 3 ♂♂ vi.17–18.40 (H.H.).

Monterrey, Nuevo Leon, 1800 ft., 2 ♂♂ 1 ♀ iv.27.41 (R.P.).

nr. Villagran, Tamaulipas, 1160 ft., 1 ♂ iv.28.41 (R.P.).

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♂♂ 2 ♀♀ v.28–29.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 200 ft., 3 ♂♂ vi.27.41 (H.H.); 1 ♂ iv.30.41 (R.P.).

El Pujal, San Luis Potosi, 100 ft., 2 ♂♂ 5 ♀♀ vii.17–21.39 (H.H.).

Hda. Potrero Viejo, Vera Cruz, 1500 ft., 1 ♀ v.5.41 (R.P.).

Tuxpango, Vera Cruz, 1500 ft., 1 ♀ v.9.41 (R.P.).

Fortin, Vera Cruz, 1600 ft., 2 ♀♀ v.4.41 (R.P.).

Ojo de Agua, Vera Cruz, 2000 ft., 2 ♂♂ 1 ♀ v.12.41 (R.P.).

Orizaba, Vera Cruz, 2000 ft., 4 ♂♂ 2 ♀♀ v.6.41 (R.P.).

60 mi. So. of Victoria, Tamaulipas, 1 ♂ 1 ♀ vii.6.36 (H.D.T.).

El Sabino, nr. Uruapan, Michoacan, 5 ♂♂ 4 ♀♀ vii.15–30.36 (H.D.T.).

Chichen Itza, Yucatan, 2 ♀♀ viii.30.36 (H.D.T.).

An extremely varied series. The species "*hermes*" may be composite.

197. **Megisto libye** Linnæus.

G. & S., **1**: 83, 655.

W., p. 212, pl. 48e.

Ho., p. 669.

Ojo de Agua, Vera Cruz, 1600 ft., 1 ♀ v.12.41 (R.P.).

198. **Megisto glaucina** Bates.

G. & S., **1**: 90, pl. 8. ff. 18, 19.

W., p. 216, pl. 49b.

Ho., p. 669.

Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ 1 ♀ v.12.41 (R.P.).

Megisto sp.

Fortin, Vera Cruz, 1600 ft., 1 ♂ v.4.41 (R.P.).

Ojo de Agua, Vera Cruz, 2000 ft., 1 ♂ v.6.41 (R.P.).

A species near *nebulosa* Butler. Differing from that South American species in having five ocelli on the under side of the fore wing.

200. **Pindis squamistriga** Felder.

G. & S., **1**: 80, 654, pl. 8, f. 24 (fig. as *zabdi*).

W., p. 224, pl. 50a.

Ho., p. 669.

Jacala, Hidalgo, 4500 ft., 2 ♂♂ vi.23–29.39 (H.H.).

El Sabino, nr. Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

Sta. Lucretia, 2 ♂♂ ix.4.39 (H.D.T.).

The two Jacala specimens are badly battered; fortunately one entire fore wing is intact on one specimen, sufficient to recognize the genus and species. This is the first record of the species from so far northeast in Mexico.

202. **Paramecera xicaque** Reakirt.

G. & S., **1**: 101, 660.
W., p. 225, pl. 50a.
Ho., p. 669.
Tancitaro, Michoacan, 6600 ft., 1 ♂ vii.25.40 (H.H.).

A battered specimen.

BRASSOLIDÆ

216. **Opsiphanes cassina fabricii** Boisduval.

G. & S., **1**: 127, 664 (as *cassiæ*).
F. (4), p. 302, pl. 51d.
Ho., p. 671.
El Bañito, Valles, San Luis Potosi, 200 ft., 3 ♂♂ 1 ♀ vi.28.40 (H.H.).

Hoffmann reports this species from both coasts as far north as Sinaloa and Tamaulipas in contrast to Fruhstorfer's report of it only as far north as Tepic, Nayarit on the west coast and no mention of it in eastern Mexico.

218. **Eryphanis æsacus æsacus** Herrick-Schaffer.

G. & S., **1**: 137, 666.
F., p. 313, pl. 64b.
Ho., p. 671.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♂♂ 1 ♀ v.28–29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♂ v.28.40 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 2 ♂♂ vi.18.39 (H.H.).

These records extend the range of the species a little further north than that given by Hoffmann. Fruhstorfer says of the species, "Everywhere rare."

MORPHIDÆ

225. **Morpho peleides montezuma** Guenee

G. & S., **1**: 119, 663 (as *peleides*).
F., p. 344.
Ho., p. 672.

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 5 ♂♂ v.29.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ vii.22.39, vi.26.40 (H.H.).

Ojo de Agua, Vera Cruz, 1600 ft., 3 ♂♂ 1 ♀ v.12.41 (R.P.).

The Ojo de Agua material is in very poor condition, especially the female. The other specimens are in good condition. The records for San Luis Potosi extend the range of the species a little to the north.

BIBLIOGRAPHY

1. GODMAN & SALVIN, Biologia Centrali-Americana, Rhopalocera, 1: 1–139. 1879–1881.
2. HAENSCH, in Seitz' Macrolepidoptera of the World, vol. 5, p. 113–171. 1909–1910.
3. WEYMER, in Seitz' Macrolepidoptera of the World, vol. 5, p. 173–283. 1910–1912.
4. FRUHSTORFER, in Seitz' Macrolepidoptera of the World, vol. 5, p. 285–356. 1912–1913.
5. HOFFMANN, Anales del Instituto de Biologia (Mexico), 11: 639–739. 1940.

OUTDOOR PROTECTION FROM MOSQUITOES*

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Even in areas where mosquito control work has been systematically conducted for many years it has not been possible, with our present means and methods, completely to eradicate the mosquito. Under conditions favorable for its rapid development, such as during summers of abundant rainfall, it becomes at times a serious interference with human comfort.

When a female mosquito bites or pierces the skin to suck our blood she injects into the wound a small amount of a poisonous substance, the chemical composition of which has not been definitely established. The effect of this injected material varies with different species of mosquitoes as well as with the susceptibility of the bitten individual. While a small number of people appear to possess a certain degree of immunity, either natural or acquired, against this poison, the great majority of us, especially children, suffer from its effects. Immediately following the bite, an itching sensation is felt which may be followed by considerable swelling. The scratching induced by the irritation may cause a secondary blood infection, especially among children, leading to serious results. The irritation may be relieved by washing the swelling with any one of the following solutions: soft soap, alcohol, glycerin, iodine or borax.

Complete elimination of mosquitoes indoors can be readily accomplished by proper screening, spraying, or fumigating. On the other hand, protection from mosquito annoyance outdoors constitutes a difficult problem, the solution of which cannot always be successfully attained.

Mosquito repellents.—Various chemicals, possessing repelling properties against mosquitoes, have been recommended and commercialized. They are applied in form of lotions, ointments or powders to the exposed parts of the body. The duration of the

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protection may vary from a short time to several hours, depending on the inherent repellent properties of the chemical, thoroughness of application, species and density of the mosquito population, degree of attractiveness possessed by the individual, and atmospheric factors.

Citronella is one of the oldest mosquito repellents used either in its natural liquid state or in combination with various other compounds. One of the early formulas recommended by Dr. L. O. Howard (1923) contains the following ingredients: oil of citronella 2 ounces, spirits of camphor 2 ounces, and oil of cedar 1 ounce. This preparation can also be made in form of a salve, if desired, by mixing in enough petrolatum or similar semisolids. One thorough application may remain effective for 1 or 2 hours. Dr. Herms (1939) finds the following formula successful: citronella 3 parts, kerosene 2 parts, and coconut oil 4 parts. To this mixture is added 1 per cent carbolic acid. Within the last few years longer lasting and more efficient repellents have been synthesized, as a result of research conducted at the Federal Bureau of Entomology in Washington and at Rutgers University (Granett 1940), in cooperation with various commercial concerns. Three of these are at present widely used, namely, dimethyl phthalate, Indalone, and formula No. 612.

Though mosquito repellents are contributing a great deal toward relief from mosquito annoyance to individuals, such as night watchmen, military pickets, mosquito workers and fishermen, compelled to remain exposed for considerable lengths of time in mosquito-infested areas, their frequent application encounters many drawbacks. First, not all the repellent mixtures thus far developed repel mosquitoes from a distance. In virtually every case the mosquito has to alight, or at least come very close to the treated surface, before the chemical acts on it. Complete and thorough coverage is, therefore, necessary, otherwise untreated spots may be bitten. Second, virtually all of the repellents cause sharp smarting on delicate parts of the skin such as eyelids, face and forehead. This irritation is apt to become rather pungent and often unbearable to many sensitive individuals under warm, humid atmospheres and other conditions when copious perspiration occurs. Third, because of the solvent

properties of the repellents, a treated individual must avoid coming in contact with varnished and painted surfaces. Either paint or varnish will be partially removed, resulting in staining of clothes or any other objects incidentally touched. Fourth, the repellent does not protect a group, much less a large outdoor audience, unless each individual is treated. Fifth, continuous feel of a greasy, somewhat irritating solvent all over one's skin becomes rather unpleasant. Unless compelled by military duty or night work, few individuals will willingly submit themselves to this treatment night after night. Instead they would rather stay indoors or in a well-screened porch.

Mosquito sprays.—In view of these objectionable features, the writer became interested in developing a mosquito spray which should, with no injury to man, animals, and plants, completely free an area from adult mosquitoes where groups of people could spend a summer evening with no mosquito annoyance and with perfect body comfort. This effort coincided with another problem, that of developing a mosquito larvicide which should kill mosquito larvæ and pupæ with no injury to fish, water fowl, and aquatic plants, offering at the same time no fire hazard. Such a product was called for in residential sections, ornamental ponds, game conservation parks, and similar places where mosquito oil was objectionable. By 1931 the New Jersey Pyrethrum Mosquito Larvicide was developed and came into wide use as a substitute for oil wherever the latter meets with objections, Ginsburg (1930). The larvicide is essentially an emulsion consisting of 66 per cent kerosene, 0.5 per cent sodium lauryl sulfate as emulsifier, 0.07 per cent pyrethrins, and about 34 per cent water. The concentrated stock emulsion is mixed just before spraying with about 10 parts of clear water, which may be taken directly from the area to be sprayed.

Preliminary tests conducted during 1934 (Ginsburg 1935) indicated that spraying with this diluted larvicide might also prove effective in ridding a given area from adult mosquitoes. Further extensive experiments carried out during 1935–36 (Ginsburg 1936, 1937) by the writer in cooperation with the various County Mosquito Commissions in New Jersey have substantiated this assumption and have established a definite method of procedure for spraying.

The experiments during these three years have given us some fundamental knowledge as well as authentic information concerning the possibility and practicability of eliminating mosquito annoyance from outdoor public gatherings without in any way interfering with human comfort and activities. We have learned how to accomplish this relief without appreciable injury to plant life. These results have also thrown some light on the physical and chemical mechanism involved as well as the rôle that each ingredient of the larvicide plays in this process. From the experience thus far gained the following principles may be evolved as guides in this work.

In order successfully to eliminate adult mosquitoes from a given area outdoors, two objectives must be attained. First, all female mosquitoes resting in the grass, shrubs, and throughout the area to be treated must be killed. This is accomplished by thoroughly spraying the entire grounds before the audience gathers. Second, the influx of mosquitoes from the surroundings into the protected area must be prevented. For this purpose the spray is directed upward, as high as the pressure permits, so as to saturate the atmosphere with a fine mist of larvicide. This air-fogging may have to be repeated two or three times during the affair, depending on the species and density of mosquitoes, the flight intensity, the direction and velocity of wind, and other atmospheric factors. It should be emphasized that, for complete protection, it is just as important to kill or incapacitate all the female mosquitoes hiding in vegetation as it is to bar those in the surroundings from flying in. The spray should be applied in highly dispersed form, as a fog or mist. The finer the liquid particles, the less will be the danger of injury to plants and the longer will it remain floating in the air. The diluted larvicide must be kept thoroughly mixed during spraying.

The mechanism involved in this process is twofold, repellency and contact killing. The female mosquito when in contact with the larvicide is either killed or paralyzed to such a degree that, for an indefinite period, she can neither fly nor bite. These symptoms are brought about primarily by the pyrethrins incorporated in the larvicide. The petroleum oil acts as a carrier for the pyrethrum. It should be mentioned here that neither an aqueous

spray of pyrethrum extract nor a kerosene emulsion when applied separately gave satisfactory protection. Evidently the combination of both ingredients is necessary for adequate protection. The water in the larvicide merely serves as the outer phase in which the two toxic ingredients are dispersed by the aid of the emulsifier.

The question has been asked: What happens to the mosquitoes in the sprayed area? The following observations may offer an explanation. When tents were sprayed inside with the larvicide, some mosquitoes were found on the ground apparently dead while others remained on the canvas in a quiescent condition. When disturbed they attempted to fly but soon again attached themselves to the canvas. They remained for some time in this partly paralyzed condition and finally either dropped to the ground or flew away. These symptoms closely resemble those observed in other insects treated with pyrethrum insecticides and can, therefore, be attributed directly to the pyrethrins incorporated in the larvicide. Again, while checking the mosquito density the writer observed on several occasions that when mosquitoes reach the treated area they abruptly change their course of flight, turning back or at a right angle. This behavior suggests repellency. Evidently mosquitoes find the oil, the pyrethrum, or both combined so disagreeable that they keep away from the treated area.

DIRECTIONS FOR SPRAYING

The concentrated larvicide is first well shaken or stirred. It is then mixed with 12 parts of water (1 quart to 3 gallons) in the sprayer. This diluted mixture is ready for spraying. During the spraying operation it should be frequently shaken or stirred in order to insure uniform distribution of the larvicide.

Procedure.—Before the affair starts, the entire area, including grass, shrubs, bleachers, sheds, benches, or any other place where mosquitoes may rest during the day, is thoroughly sprayed with the diluted larvicide. This should kill all mosquitoes as well as many other insects hiding in the grass, shrubs, and other places. The next object is to prevent mosquitoes from the surroundings from coming into the protected area. For this purpose the spray is directed upward so as to saturate the atmosphere with a fine mist or fog of the larvicide. If the spray is applied against the

wind the fine mist or fog will drift with the wind throughout the area. This entire operation should be finished before the gathering takes place. Just about dusk or when the mosquitoes from the outside begin to fly in, another fogging is necessary. For this purpose the spray is applied as high as the sprayer permits and primarily on the side from which the wind is blowing. This mist in the air wards off mosquitoes from outside the treated area. If no noticeable wind prevails it may be necessary to fog all around the area, directing the spray upward so as to keep the inflying mosquitoes away. A thorough fogging about the time when the mosquitoes start coming in should be sufficient for the rest of the evening. Under very heavy infestations, where the mosquitoes are coming in large numbers, a second fogging about 9:30 may be necessary.

Apparatus Required.—(1) on small areas, such as backyards, porches, and private lawns, a garden sprayer, knapsack sprayer, bucket pump, or electric sprayer capable of producing a fine spray, about 10 or 15 feet high, may be used with success.

(2) For spraying large areas, such as picnic grounds, stadiums, and open air theaters, a power sprayer capable of developing a pressure of 200 pounds or more per square inch and equipped with a spray gun is necessary. The larvicide has been found most efficient in protecting outdoor audiences on comparatively large areas where power sprayers can be used.

Precautions.—Before attempting to treat an area, one should make a thorough survey in order to ascertain the following points: sources of mosquitoes; possible mosquito resting places; direction of wind; type of vegetation present; water supply for mixing the larvicide; kind of spraying outfit necessary; nature of gatherings; and any difficulties that may be anticipated during the spraying operation. This information should enable the operator to plan his method of procedure.

PRESENT STATUS OF THE NEW JERSEY PYRETHRUM MOSQUITO LARVICIDE

Since this spray was introduced, numerous outdoor evening concerts, carnivals, church parties, community gatherings, and lawn parties have been fully protected from mosquitoes either directly by the County Mosquito Commissions at a nominal cost,

or indirectly through their assistance, guidance, and advice. The number of persons present on these occasions varied from small groups to many thousands. Records show that in several instances some 20,000* persons in one gathering have enjoyed an open air evening concert with no mosquito discomfort as a result of spraying the stadium where the affair was held. When the larvicide was sprayed as directed, no injury has resulted to grass, shrubs, trees, ornamental plants or aquatic plants. Up to and including 1942, its use increased with each successive season.

Prior to 1934 most of the pyrethrum used in this country came from Japan, and small amounts from Dalmatia and the Kenya Colony in British East Africa. By 1939 the picture was reversed; most of our pyrethrum was imported from Kenya and very little from Japan. When World War II broke out, cultivation of pyrethrum in the British possessions, for various reasons, decreased. Shipping shortage and submarine losses still further curtailed the flow of pyrethrum flowers to this country. After Pearl Harbor, practically all the available and potential supplies of pyrethrum were taken over by the United States Government for army use. At present the War Production Board does not allow the use of pyrethrum for preparing the larvicide. Thus, the excellent record of this newly developed method for temporary relief from biting female mosquitoes has been suddenly terminated for the duration or until enough pyrethrum becomes available to supply a surplus, above the amount necessary for our armed forces.

Intensive testing is now being conducted with various other chemicals as possible substitutes for pyrethrum. At this date, however, none has proved equal to pyrethrum from the standpoints of effectiveness against the mosquito and of safety to man, animals, and plants.

LITERATURE CITED

GINSBURG, J. M. 1930. Studies of pyrethrum as a mosquito larvicide. Proc. 17th Ann. Meet. N. J. Mosq. Ext. Assoc., p. 57.

———. 1935. Larvicides and method for temporary protection from adult mosquitoes in limited areas. Proc. 22nd Ann. Meet. N. J. Mosq. Ext. Assoc., p. 147.

* Essex County Symphony Society, at the Newark School Stadium.

———. 1936. Protection of outdoor gatherings from the mosquito pest. Proc. 23rd Ann. Meet. N. J. Mosq. Ext. Assoc., p. 166.

———. 1937. Principles underlying the protection of outdoor meetings from the mosquito pest and methods of application. Proc. 24th Ann. Meet. N. J. Mosq. Ext. Assoc., p. 5.

GRANETT, P. 1940. Studies of mosquito repellents. Jour. Econ. Ent., 33(3): 563–71.

HERMS, W. B. 1939. Medical Entomology. MacMillan, New York.

HOWARD, L. O. 1923. Remedies and preventives against mosquitoes. U. S. D. A. Farmers' Bull. No. 444.

VANNOTE, R. L. 1937. Methods of applying the larvicide as a repellant. Proc. 24th Ann. Meet. N. J. Mosq. Ext. Assoc., p. 11.

NEW NEOTROPICAL THECLINÆ (LEPIDOPTERA, LYCÆNIDÆ)

BY HARRY K. CLENCH

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The following new Theclinæ have come to my attention recently, two of them during the arranging of the Neotropical Lycænidæ in the collection of the Museum of Comparative Zoölogy (M.C.Z.) and one in a loan of study material from the American Museum of Natural History.

Thecla caramba, new species

Eyes ringed with pale green. *Frons* metallic green. *Collar* above obscure, laterally brown. *Palpi* rusty gray, terminal sediment dark. *Antennæ* black above, white annulate below. *Thorax* above black-brown (scaled with metallic blue?), covered anteriorly, laterally and posteriorly with long, back-directed hairs, bluish in color; below with moderately long, red-brown hair. *Abdomen* above metallic blue, becoming gray towards the anal extremity; below pale yellow, or rich cream. *Legs* largely black, ringed narrowly and infrequently by white.

UPPERSIDE:

Male. Both wings dark, lustrous blue, with a purple luster. *Fore wing* with a narrow outer marginal border, thickening slightly at the apex. *Hind wing* with costa gray-brown, and inner margin gray. Outer margin very narrowly black. Anal lobe rusty. Outer margin *very slightly* produced at the vein-ends from M_1 to the anal angle, but no indication of any tails is present. *Fringe* of both wings brown, on hind wing paler outwardly between the veins.

UNDERSIDE:

Male. Both wings bright pea-green. *Fore wing* with a gray area from Cu_2 to the inner margin. The green along this gray area is bluish, basad. On the outer margin the green extends down to 2A. *Hind wing* with a white spot on the costa, near outer angle, basally edged with dark red. A similar, but post-discal, spot in M_2–M_3 and one in Cu_1–Cu_2. In Cu_2–2A is a white dash, basally edged with red, and in 2A-inner margin is a similar, but heavier dash. Anal lobe red, extending on outer margin to Cu_2. In Cu_1–Cu_2 is a submarginal red dash. *Fringe* of both wings rusty-red, outwardly paler on the hind wing between the veins.

Length of fore wing: Male, 15 mm.

Holotype, male, Massaranduba-Blumenau, Brasil (ex coll. E. I. Huntington (no. 1009)); in the American Museum of Natural History.

Remarks. Evidently closely allied to *amyntor* Cramer,[1] of which, unfortunately, no males have been examined. The holotype of *caramba* was compared with a female (in M.C.Z., no data, ex coll. A. G. Weeks) of *amyntor*, the description and figure of Draudt (1919, *in* Seitz, Macrolep. World, 5, p. 762, pl. 153 i), and Cramer's descriptions and figures of *amyntor* (*loc. cit.*) and *menalcas* (1782, Pap. Exot., 3, p. 117, pl. 259, figs. A and B).

Above, *caramba* differs from *amyntor* (of Draudt) in the narrower, better defined marginal border. Below, from the female at hand, the present species seems to have more of an anal lobe and less prominent white markings. The absence of a tail is probably very significant, and would seem to connect *amyntor* to the *acaste* group, particularly to those members of that group with a green frons. It certainly destroys Draudt's character for splitting the "*amyntor*-group" into two sections (*i.e.*, the tailed section, comprising the true *amyntor* group, to which *caramba* obviously belongs, and the tailless section, more aptly called the *acaste* group, and to which *caramba* bears little (relative) resemblance.

Thecla punona, new species

Eyes ringed with white. *Frons* with moderately profuse, long, erect pale gray hairs. *Collar* above with brown and gray hairs intermingled; on the sides, white. *Antennæ* largely white below, black above, but with thin annulations of each extending into the other; club black. *Thorax* black above, with sparsely strewn bronzy-brown hairs; below with pallid gray hair, quite profuse. *Abdomen* gray tan above, gray below.

UPPERSIDE:

Female?. Both wings slightly lustrous brown. *Hind wing* with outer margin from M_3 to the anal angle scalloped, and with a narrow whitish marginal thread-line from Cu_2 to 2A. *Fringe* of both wings dirty white, basally darker; that of hind wing obscurely dark at the vein-ends.

UNDERSIDE:

Female?. *Fore wing* tan. A post-discal, slightly curved, dark brown line, outwardly white, proceeds from costa to Cu_2. Immediately without this line at the apex is a hoary area, extending from costa roughly to M_3. A sub-

[1] 1779, Pap. Exot., etc., 1, p. 76, pl. 48, fig. E.

marginal, frequently indefinite line crosses faintly through this, increasing in visibility below it until its disappearance at 2A. *Hind wing* hoary gray, darker on the outer margin. A submarginal row of faint yellowish or pallid-fulvous lunules parallels entirely the outer margin. A curved, irregular, discal, brown line, tan within and white without, crosses from costa to inner margin, and a post-basal, similar one also, though necessarily shorter. The two close off an area, slightly darker than the surrounding ground, which is just basad of the center. Occasionally the ground color is so disposed as to give the appearance of a row of pale gray lunules capping the yellowish ones on the outer margin. *Fringe* similar to the upperside but rather darker.

Length of fore wing: Female?, 9.5–11 mm.

Holotype, female(?), Puno, Peru, 12,500 feet, Nov. 1, 1898 (Wm. J. Gerhard).

Paratypes, two females(?), same data as holotype.

Holotype and one paratype, no. 26258 in the M.C.Z. One paratype in the collection of the author.

Remarks. Rather closely allied to *oribata* Weymer[2] and possibly only subspecifically distinct from it. The principal differencse are: the less apically produced fore wing and less anally produced hind wing (if Weymer's figure is correct); the less distinct outer row of spots on the fore wing below, and the less apparent submarginal line on the hind wing below; the more prominent basal dashes; the less distinctly black-checked fringe, particularly on the hind wing. A single specimen from Chulumani, Bolivia (Nov. 28, 1898, W. J. Gerhard), not made part of the type series, approaches *oribata* in several of these respects.

Weymer's figure shows the lines on the underside to be quite dark, almost black, while in *punona* they are brown. It is probable, however, that the figure errs somewhat in this respect.

Draudt (1919, *in* Seitz, Macrolep. World, 5, p. 760, pl. 153 h) described a new species under the name of *anosma*, which he later (Seitz, add. and corr., p. 823) synonymized to *oribata*. In his description he mentioned "incoherent dark lunular spots" and "longer small tail on the lower median vein" neither of which is particularly clear. The latter particularly would seem to exclude it entirely from the *culminicola*-group. It is presumed that by "median" he meant "cubital."

[2] 1890, Lepidopteren gesammelt . . . von A. Stübel (Rhopalocera by Weymer), p. 123, pl. 4, fig. 8.

Thecla kalikimaka, new species

Thecla hemon: Hoffman, 1940, Anales Inst. Biol. Mex., 11, p. 704 (no. 586) (*nec* hemon Hübner).

Eye ringed obscurely with white. *Frons* brown. *Collar* brown. *Antennæ* black-brown, club dull fulvous; below, white annulate, club brighter fulvous. *Palpi* brown, slightly hoary within. *Thorax* metallic green-blue above, slightly hairy; below, covered with uniform gray-brown hair. *Abdomen* above green-blue, below brown. *Legs* brown-black, tarsal segments white annulate.

UPPERSIDE:

Male. Both wings somewhat bronzy green. *Fore wing* with a compound scent-pad consisting of a dark dash across the cell-end and a rectangular brown patch just beyond. Outer margin moderately heavily edged with brown, thickening considerably towards the apex. The basal limit of this brown is very tenuous and indefinite. *Hind wing* with a small anal area of brown, and two tails, one each at Cu_1 and Cu_2, the latter longer and emitted tangentially. Anal lobe deeply incised, as is usual in this group.

UNDERSIDE:

Both wings brown. *Fore wing* with a faint, dull, metallic green iridescence. Paler on inner margin. A discal dark brown line crosses from costa to Cu_2, quite straight. *Hind wing* with a straight discal line from Rs opposite the outer angle to just beyond Cu_2 in the center of the wing. From there it becomes metallic green, and proceeds to 2A, where it angles sharply basad and terminates at the inner margin. A submarginal line starts at about M_2 and proceeds parallel to the outer margin, reaching just beyond Cu_2 where it angles basad, to terminate at the inner margin, edged inwardly from Cu_2 with a few metallic scales. A pale, hardly noticeable marginal line runs from outer angle to apex, becoming very obscurely greenish from Cu_1 on. Anal region restrictedly irrorated with pale scales. A faint line, post-basal, starts on costa and proceeds to lower cell-end. *Fringe* of both wings brown.

Length of fore wing: Male, 16 mm.

Holotype, male, Jalapa, Mexico, date and collector unknown, ex coll. A. G. Weeks, Jr.

Paratype, male, same locality, Sept. 8, 1884 ("Morrison"), ex coll. F. A. Eddy.

Holotype, M.C.Z. 26257. Paratype in the author's collection.

Remarks. Apparently most closely allied to *mavors* and *triquetra* (references and authorships of these names below). From both it differs in the brown color of the underside, which in these species is bright metallic green or blue. The lines below are less apparent than in either of the two species (except that in *kalikimaka* there is a discal line on the fore wing, lacking in

mavors). Above it differs from *triquetra* in the green color (blue in that species), and from *mavors* in the lack of a pale, almost white, anal line. The apical and marginal border of the fore wing appears slightly heavier than in either *mavors* or *triquetra*. It would seem closest to *mavors*, since it has the two tails of that species, as opposed to the single one of *triquetra*.

A brief discussion of the species of this group (as limited by Draudt, p. 750) might not be amiss.

Thecla mavors Hübner (1818, Zutr. zur Samml. Exot. Schmett., 1st. Hund., p. 31 (no. 95), figs. 189, 190). Quite variable, but whether racially or not cannot be determined from the material at hand The male is metallic green above, with a compound scent-pad, and is bordered narrowly and indistinctly with black-brown on the fore wing. Hind wing at the anal angle edged with very pale green, almost white. Below green, fore wing brown on inner margin, otherwise practically immaculate. Hind wing with a discal and submarginal line, each angled basad at Cu_2–2A. Outward of the latter is a band of brownish maroon from M_1 to the anal angle. Anal lobe similarly colored. Two tails, the larger at Cu_2 tangentially emitted.

Female, brown above and below. The latter surface crossed on both wings by thin brown lines; two on fore wings, parallel to the outer margin, and a short one crossing the cell-end. Another pair on hind wing, also parallel to the outer margin, but angling basad at Cu_2-2A. A post-basal line commences on costa, crosses cell-end and stops.

Specimens in the M.C.Z. from Suapure, Venezuela; Cusilluni, Bolivia; Cumato Arepo, Savanna, Trinidad; Rio Tapajoz, Brasil.

A Suapure female has the two lines on the hind wing abnormally close together, but whether or not this is an individual variant cannot be stated without additional material.

Thecla triquetra Hewitson (1862–1869, Ill. Diurn. Lep. Lycænidæ, p. 76, pl. 28, figs. 17, 18, 19). Differs from *mavors* in the male by being blue above, having but one tail (also tangentially emitted), the bluer color below, and the presence of a discal line on the fore wing, and heavier ones on the hind wing. Females differ from *mavors* females chiefly in the lack of a Cu_1 tail.

Otherwise they appear very similar. There is, perhaps, a slight difference in the shape of the hind wing, but more specimens are needed to confirm it.

In the M.C.Z. from Blumenau and Rio de Janeiro, Brasil.

Thecla paupera Felder (1865, Reise Novara, Lep. 2, p. 246, pl. 31, fig. 15). May be distinguished from the above in the male by the dark green color and the lack of a scent-pad on the fore wing. Differs below in that the inner of the two longest lines touches the outer at the anal angle.

Apparently not in the M.C.Z. (see under *ella*).

Thecla drucei Lathy (1926, Ann. Mag. Nat. Hist., (9) 17, p. 41). This species, also not in the M.C.Z., is figured in the Trans. Ent. Soc. London, 78, pl. 9, fig. 9 (plate accompanying paper that begins on p. 133). It apparently belongs near *paupera* and *harrietta,* but differs, in the male, by the possession of a scent-pad. There are other differences as well.

Thecla ella Draudt (1919, *in* Seitz, Macrolep. World, 5, p. 750, pl. 148 b as *mavors*). Differs from *paupera* in that the inner line below on the hind wing is w-shaped at the anal angle. This is the difference brought out by Draudt. He noted the fact that *paupera* was rare, and very likely based this difference on the figure of Felder, which does show no "W" at the anal angle of the hind wing below. This character, however, may be very faint (as in the single specimen here provisionally assigned to *ella*), and consequently overlooked when Felder's specimen was figured.

A single specimen in the M.C.Z. (Bogota, Colombia?) ex coll. A. G. Weeks, may possibly be this species. It has, however, much heavier borders above than Draudt's illustration shows, and narrower lines below. It might also be *paupera,* but again the markings below are all thinner than Draudt's and Felder's illustrations show.

Thecla harrietta Weeks (1901, Can. Ent., 33, p. 294). This is a perfectly good species, allied to *paupera* and *ella.* Besides the greatly differing color above, the lines below are rather dif-

ferent, the central apex of the "W" being rather shorter than in the specimen cited above, and in Draudt's figure of *ella*. The discal line on the fore wing extends into the Cu_2–2A interspace, which it apparently does not in the other species. In other Theclinæ, however, this character has been found to be individually variable.

One specimen in the M.C.Z. (Type, M.C.Z. no. 16673) from Coroico, Bolivia, April 20, 1899 (Wm. J. Gerhard).

NOTE ON THE DEATH-FEINT OF BRUCHUS OBTECTUS (SAY)

The common bean weevil, *Bruchus obtectus*, exhibits a wide variation in the duration of its comparatively brief death-feint. Out of 283 freshly emerged beetles, only 72 could be induced to feign death. Although dropped from a height of 12 inches, having their thoraxes pinched, being rolled between the thumb and forefinger, 211 of the weevils refused to perform in spite of all the handling. The 72 that actually went into death-feints, frequently did so, with comparatively little trouble. A slight disturbance such as touching them with the tip of a pencil, or causing them to fall one inch, or gently pressing the sides of the thorax brought about the desired reaction.

The temperature during these tests was 70° F. For the 72 beetles that reacted, the duration of the feint varied in length from 1 to 300 seconds. The duration of the weighted, arithmetic average death-feint was 33.5 seconds, and the standard deviation was 74.8. The following table shows the duration of the death-feint in the 72 different beetles that reacted:

No. beetles	Length of death-feint	No. beetles	Length of death-feint	No. beetles	Length of death-feint	No. beetles	Length of death-feint
	Seconds		*Seconds*		*Seconds*		*Seconds*
2	1	1	12	5	30	1	75
4	2	2	14	1	32	1	78
3	3	6	15	1	33	1	80
1	4	3	17	1	35	1	100
5	5	1	18	1	40	1	105
1	6	5	20	1	50	1	250
2	8	1	22	1	53	1	290
2	9	1	23	1	57	1	300
3	10	3	25	1	60		
2	11	1	29	2	70		

HARRY B. WEISS.

DIFFERENTIATION OF FEMALES OF CERTAIN SPECIES OF CULEX BY THE CIBARIAL ARMATURE

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The purpose of this paper is to describe characters of the cibarial (or "pharyngeal") armature of the *Culex* found in the southeastern United States. These characters support the usual subgeneric classification and serve in addition to distinguish females, previously considered indistinguishable, of certain of the species commonly placed in the subgenus *Melanoconion* (e.g., by King, Bradley, McNeel, 1942).

The cibarial armature has been used by a number of authors in separating the subgenera and certain Old World species of *Anopheles*. Christophers (1933) gives a good account of the structures involved in *Anopheles*.

The armature lies on the posterior margin of the anterior pump of alimentary canal. This pump has usually been called the pharynx, but Snodgrass (1943) has pointed out that it is in reality the cibarium. The second pump is the true pharynx. The ventral surface of the cibarium is sclerotic. This sclerotized area ends posteriorly in a broadly concave margin lying between the two cibarial cornua, which are apodemal muscle attachments at the posterior end of the cibarium. The cibarial armature, which is present only in females, consists of a series of sclerotized projections or teeth along the margin between the cornua.

With a little practice these structures can be studied about as easily as the male genitalia. The technique used is as follows: The head is placed in 10 per cent potassium hydroxide and heated for a short time. Then it is placed in water on a slide and under a binocular microscope the entire outer wall of the head is broken away in large pieces by means of fine needles. The pharynx and cibarium, attached to the hypopharynx, may now be seen within

[1] Acknowledgment for both helpful advice and specimens for dissection is made to Major Stanley J. Carpenter and Captain Woodrow W. Middlekauff.

and are transferred, with or without separation from the other mouthparts, to a drop of chloral hydrate medium (Berlese's medium) on a slide. Here the pharynx is pulled away from the cibarium. The cibarial armature will probably still not be clearly visible because of the imbricated sclerotized teeth in the membrane of the dorsal surface of the cibarium between the cibarial cornua. Therefore, this membrane with its imbricated teeth is dissected away from the dorsal surface of the cibarium in order to expose clearly the armature on the ventral surface. This membrane should be preserved, however, since its imbricated teeth offer characters of importance. The mount is completed with a coverglass. The separation of individual teeth as recommended by Christophers (1933) for *Anopheles* has not proved to be possible with *Culex*.

The following key separates the species of *Culex* found in the southeastern United States into groups on the basis of female cibarial armatures. *Culex atratus* Theobald and *C. bahamensis* Dyar and Knab, found in this area only on the Florida Keys, have been omitted because of the lack of specimens for study.

1. Cibarial armature consisting of 25 to 35 small, slender teeth; imbricated teeth of the membrane of dorsal surface of cibarium between cornua small, lightly sclerotized, brownish 2
–. Cibarial armature consisting of 3 to 8 large, blunt teeth; imbricated teeth of membrane of dorsal surface of cibarium between cornua large, heavily sclerotic, blackish (Subgenus *Melanoconion*) 3
2. Cibarial teeth not longer than width of a cibarial cornu.
(Subgenus *Culex* s. str.) *pipiens* Linnæus, *quinquefasciatus* Say, *tarsalis* Coquillett, *salinarius* Coquillett, *nigripalpus* Theobald
–. Cibarial teeth much longer than width of a cibarial cornu.
(Subgenus *Neoculex*) *apicalis* Adams
3. Cibarium with three teeth . . *pilosus* (Dyar and Knab)
–. Cibarium with seven or eight teeth.
erraticus Dyar and Knab, *peccator* Dyar and Knab

These characters are shown in greater detail in the figures. Except to strengthen the recognized subgeneric classification, the cibarial characters contribute little to our knowledge of the subgenera *Culex* s. str. and *Neoculex*.

The three remaining species, however, are externally indistinguishable in the females except that most specimens of *errati-*

cus have some coarse, golden, mesoscutal scales and the broad, appressed, occipital scales are limited to a band along the eye margin, while in the other two species the mesoscutal scales are usually dark and the occiput is usually mostly covered with broad, appressed scales. These characters do not hold for every specimen. The cibarial characters thus make possible the identification of female *pilosus*.

It is interesting to note that Edwards (1932), on the basis of larval characters, placed *pilosus* in the subgenus *Mochlostryax*,

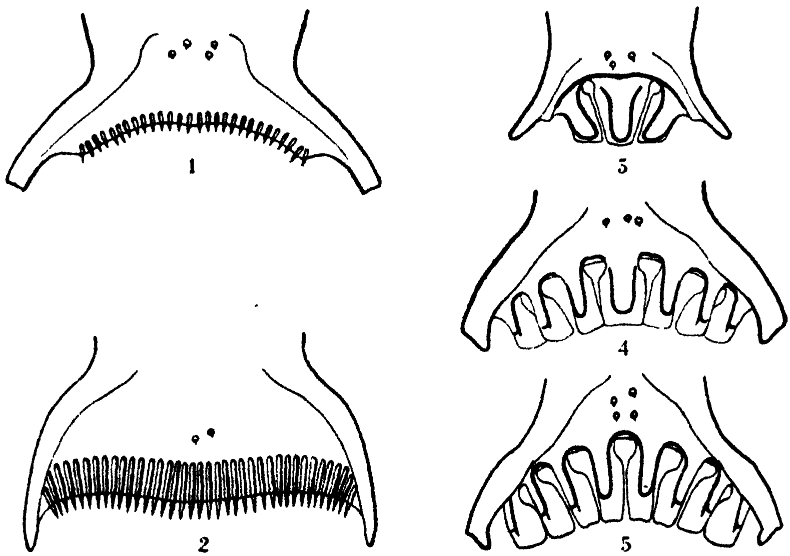

FIG. 1. Cibarial armatures of: 1, *Culex* (*Culex*) *restuans*; 2, *Culex* (*Neoculex*) *apicalis* Adams; 3, *Culex* (*Melanoconion*) *pilosus* (Dyar and Knab); 4 and 5, *Culex* (*Melanoconion*) *erraticus* Dyar and Knab.

and *erraticus* and *peccator* in *Melanoconion*. The cibarial armatures of the three species here discussed support this classification, but until these characters have been studied for the numerous tropical species of this group, it is not advisable to consider the cibarial armature as a subgeneric character.

The cibarial armatures of about twenty specimens of *C. pilosus* have been examined and found quite uniform in structure. Several of those studied were from a series reared from *pilosus* larvæ by Mr. Wm. V. Reed. The armatures of forty other female

specimens of *Melanoconion* were examined. All were seven- or eight-toothed. Most of them, on the basis of the characters of the vestiture already mentioned, were presumed to be *C. erraticus* and two were from a series reared from *erraticus* larvæ by Lt. Basil G. Markos. Among the six specimens studied having seven or eight cibarial teeth but vestiture as in *pilosus* and *peccator*, two from different localities were collected with males of *peccator* and are, no doubt, females of that species. Both of these had but seven teeth.

LITERATURE CITED

CHRISTOPHERS, S. R. 1933. The fauna of British India, Diptera, Vol. IV, Family Culicidæ, Tribe Anophelini, vi + 371 pp., illus.

EDWARDS, F. W. 1932. Diptera, Fam. Culicidæ, in Wytsmann's Genera Insectorum, fasc. 194, 258 pp., illus.

KING, W. V., G. H. BRADLEY, AND T. E. MCNEEL. 1942. The mosquitoes of the southeastern states, U. S. Dept. Agr., Misc. Publ. 336, 96 pp., illus.

SNODGRASS, R. E. 1943. The feeding apparatus of biting and disease carrying flies: a wartime contribution to medical entomology, Smithsonian Misc. Colls., vol. 104, no. 1, pp. 1–51, illus.

INSECT RESPONSES TO COLORS

BY HARRY B. WEISS

The purpose of this article is to call attention to the approximately similar qualitative results obtained by various workers who used widely different methods of approach and technique in studying the behavior of insects to different wave lengths of light. No attempt will be made here to describe the techniques, as they are already matters of record. In fact they differ as widely as the methods of approach.

Bertholf (1, 2) exposed the honey bee, and the fruit fly Drosophila to two translucent glass plates of equal size, one illuminated with white light and the other with monochromatic light obtained by means of a quartz prism. The intensity of the white light was changed until its effect on the photopositive response of the insects was equal to that of monochromatic wave lengths in different portions of the spectrum. He found that for the honey bee, the stimulating efficiency increased from zero at 6450 Å to a maximum of 100 arbitrary units at 5500 Å, then decreased to 10 at 4350 Å after which it rose rapidly to a second maximum of 450 at 3650 Å and then rapidly declined to zero at about 2800 Å.

As for Drosophila, Bertholf (2) stated ". . . starting with the longer wave lengths the efficiency is very low until it starts to rise at about 5750 Å; from here it rises to a maximum in the so-called visible spectrum at 4870 Å . . . ; from this wave length it decreases again at 4250 Å; then it rises suddenly and attains a maximum value at 3650 Å . . . ; from here it decreases rapidly to zero at 2540 Å." Bertholf worked with 30 wave lengths from 2300 Å to 7000 Å.

Weiss *et al.* (6, 7, 8) exposed approximately 15,000 insects, both adult and larval forms, mostly diurnal, but some nocturnal, involving 40 species in various orders to 10 wave-length bands of light of equal physical intensities from 3650 Å to 7400 Å. Each test lasted from 15 to 30 minutes and a group of 100 or more of each species was used for from one to three successive tests. The

composite group behavior pattern, both for larvæ and adult insects indicated that the stimulating efficiency increased only slightly from zero at 7200 Å to 5750 Å. From here it rose to a maximum at 4920 Å. It then declined to a comparatively low level at 4640 Å from which point it ascended to its peak maximum level at 3650 Å.

These authors found that, regardless of the relative positions of the wave-length bands, the insects made approximately the same selections time after time, also that when a second and third test followed the first, there was a shifting of individuals that went to the different colors, but no change in the final result. In addition some species such as the Japanese beetle and the Colorado potato beetle responded to what were unattractive wave lengths under equalized physical intensities, when the intensities of such unattractive wave lengths were increased. In other words, it was possible to vary the behavior pattern by varying the intensities.

Crescitelli and Jahn (3), approached the problem from the standpoint of the electrical responses of the dark-adapted grasshopper eye. "Leads were taken with silver-silver chloride electrodes from fluid-filled chambers about each eye. The entire surface of one eye was illuminated, and the other eye was kept in darkness. Records were obtained by means of a cathode ray oscillograph. For the experiments on colored light Corning color filters were placed between the light source and the eye." Six wave-length bands were employed, extending from about 4000 Å to 7000 Å. "The relative intensity transmitted through each of these six filter combinations was determined by means of a thermopile and galvanometer. The infra-red radiations were completely removed from the stimulating light by using 5 cm. of water and a Corning (AKLO) heat absorbing filter."

These authors studied the change in form of the electrograms of the grasshopper eye under variations in intensity of the stimulating light and also the quantitative aspects of the response in relation to the quality of the stimulating light. They found that there was apparently no specific effect of wave length on the electrical response of the whole dark-adapted grasshopper eye. At equalized intensities there were decided differences in wave

form with the six different spectral bands, but these disappeared and the color responses were exactly matched when the intensities of the different spectral regions were properly adjusted. Quoting again from their paper: "The form of the electrical response of the dark-adapted grasshopper eye to brief stimulation by white or colored light varies according to the intensity of the light. At very low intensities the response is diphasic, the initial positive phase of which resembles the a-wave of the vertebrate electroretinogram. As the intensity is increased the positive phase decreases and changes its position while the negative phase becomes increasingly prominent. Eventually the positive phase is completely eliminated and the electrogram takes the form of the typical high-intensity response. The order of effectiveness of the different colors in causing this change in wave form is: green, blue, violet, orange-red, red."

The curve relating the magnitude of the potential to the wave length had a peak in the green region of the spectrum, and declined sharply toward the red and less sharply toward the violet. The magnitude of the electrical response was found to be definitely related to the quality of the stimulating light and the form of the response to be influenced by the intensity of the stimulating light, either white or colored.

Jahn and Crescitelli (5), also studied, in the same manner, the electrical responses of the compound eye of the moth *Samia cecropia*, in relation to the quality and intensity of the stimulating light. Part of their conclusions are quoted as follows: "The electrical responses of the moth and grasshopper eyes to wave length are surprisingly similar. For both animals the same type of graph is obtained when the relative magnitude of the potential is plotted against wave length. This graph has a general similarity to the absorption curve of visual purple. Another aspect of the electrical response to wave length concerns the fact that no specific effects of wave length on the electrograms are discernible. By properly adjusting the intensity, the responses to one color may be exactly matched with the response to any other color, indicating that the differences in the responses to different colors of equal intensity are caused merely by differences in sensitivity and are not effects of wave length *per se.*"

In the case of the moth eye the maximum response was obtained with the green band. The responses dropped sharply toward the red band and less sharply toward the violet.

Graham and Hartline (4) studying the responses of single visual sense cells of Limulus to visible light of different wave lengths found that when the energy of the stimulating light of different wave lengths was approximately equal, the response to green was stronger than the responses to either violet or red. When the energy was increased in the red and violet their level of response was raised and when the intensities of the different wave lengths were adjusted so that the responses were equal, there was no effect of wave length as such, indicating that single sense cells can gauge brightness, but cannot distinguish wave length. The relative energies of the various wave lengths required to produce the same response, after being adjusted in inverse ratio to the degree of their absorption yielded a visibility curve for a single visual sense cell that had its maximum in the green near 5200 Å and that declined symmetrically on each side to low values in the violet near 4400 Å and in the red near 6400 Å.

Thus the visibility curves of a single visual sense cell of Limulus, although not an insect, of the eye of a grasshopper, a diurnal insect, and of the eye of a Cecropia moth, a nocturnal insect, are qualitatively similar to the curve of the relative stimulating efficiency of different wave lengths of light for Drosophila, as reported by Bertholf and to the behavior curves for the numerous adult and larval forms of diurnal and some nocturnal insects as reported by Weiss *et al.* These curves are not identical because of the different methods of approach and technique but they are all strikingly similar for the visible portion of the spectrum. All were obtained under wave lengths of equalized physical intensities. Hartline and Graham and Crescitelli and Jahn by properly adjusting the intensity were able to match the response to one color with the response to any other color and Weiss *et al.*, in their behavior studies found that insects responded to what were unattractive colors under equalized intensities, when the intensities of these colors were increased.

Crescitelli and Jahn (3) report that other authors who worked with pigeon eyes and the eyes of certain vertebrates also found

that wave form difference are simply intensity differences and that the electrical response to different wave bands could be duplicated by adjusting the intensity of the different bands.

Thus it appears that both the electrical responses of the insect eye and the motor responses of the insect itself to different colors of equal intensity are due to differences in sensitivity, or to the absorption of light, which varies with wave length, by the primary photosensitive substance of the visual sense cells, and are not the effects of wave length by itself.

REFERENCES

1. BERTHOLF, L. M. The distribution of stimulative efficiency in the ultra-violet spectrum for the honey bee. Jour. Agr. Res. 43 (8): 703–713. 1931.
2. BERTHOLF, L. M. The extent of the spectrum for *Drosophila* and the distribution of the stimulative efficiency in it. Zeitsch. Vergl. Physiol. 18: 32–64. 1932.
3. CRESCITELLI, FREDERICK, AND THEODORE LOUIS JAHN. The electrical response of the dark-adapted grasshopper eye to various intensities of illumination and to different qualities of light. Jour. Cellular and Comp. Physiol. 13: 105–112. 1939.
4. GRAHAM, C. H., AND H. K. HARTLINE. The response of single visual sense cells to lights of different wave lengths. Jour. Gen. Physiol. 18 (6): 917–931. 1935.
5. JAHN, THEODORE LOUIS, AND FREDERICK CRESCITELLI. The electrical responses of the Cecropia moth eye. Jour. Cellular and Comp. Physiol. 13: 113–119. 1939.
6. WEISS, HARRY B., FRANK A. SORACI, AND E. E. MCCOY, JR. Insect behavior to various wave lengths of light. JOUR. N. Y. ENT. SOC. 49: 1–20; 149–159. 1941. 50; 1–35. 1942. 51: 117–131. 1943.
7. WEISS, HARRY B., E. E. MCCOY, JR., AND WILLIAM M. BOYD. Group motor responses of adult and larval forms of insects to different wave lengths of light. JOUR. N. Y. ENT. SOC. 52: 27–43. 1944.
8. WEISS, HARRY B. The group behavior of 14,000 insects to colors. Ent. News 54: 152–156. 1943.

HIBERNATION OF THE SYRPHID FLY, LATHYROPHTHALMUS ÆNEUS SCOP.

Lathyrophthalmus æneus Scopoli has the interesting habit of hibernating gregariously in old nests and burrows of Aculeate Hymenoptera. On several occasions in the last few winters the writer has encountered the species in open tunnels of various anthophorid bees situated in vertical banks or cliffs. In February, 1944, however, several hundred specimens were found hibernating in empty nests of the black and yellow mud-dauber, *Sceliphron servillei* (Saussure), in various localities in the San Joaquin Valley, California. The localities included Merced in Merced County, Chowchilla and Berenda in Madera County, Tulare and Tipton in Tulare County, and Kingsburg and Fowler in Fresno County. In all cases the nests utilized for hibernation were situated under bridges or culverts. Usually five or six individuals, more rarely eight or nine, occupied a single empty mud cell. Prof. F. M. Hull, who very kindly made the identification, reported that both sexes were present in a series of approximately thirty specimens submitted to him, with the females slightly predominating.

The only other hibernating insect using these nests and approaching the syrphids in abundance was the elm leaf beetle, *Gallerucella xanthomelæna* (Schrank). These, however, were hibernating elsewhere in the vicinity under a variety of different conditions, whereas the syrphids appeared to exhibit a marked preference for this particular habitat.—E. GORTON LINSLEY.

TWO NEW SUBSPECIES OF LYCÆNOPSIS PSEUDARGIOLUS BDV. & LEC. (LEPIDOPTERA, LYCÆNIDÆ)

BY HARRY K. CLENCH
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The following new subspecies have recently come to my attention and appear to be worthy of names. As is well known, the interrelationships of the various named entities of North American *Lycænopsis* are not as yet satisfactorily determined. The following two have, therefore, been placed under *pseudargiolus* as simple races. It is possible that later on they will be classified differently.

Lycænopsis pseudargiolus sidara, new subspecies

UPPERSIDE:

Male. Both wings uniform, slightly violet blue, with a thin blackish border on each. *Fringe* white, dark toward the apex of the fore wing and occasionally faintly at the vein-ends of both wings.

Female. Both wings shining blue, with a violet tinge. *Fore wing* with a broad, dark, marginal border, thickest at the apex. Costa with the blue whiter and the marginal brown border slightly extended basad. *Hind wing:* Costa shaded with brown. Outer margin with a thin black line, basal to which is a row of spots, one to each interspace. *Fringe* of both wings similar to that of the male.

UNDERSIDE:

Male. Both wings white, grayish in the basal half. *Fore wing* with the cell closed by a faint dark line. A thin marginal line runs from costa to inner margin, basal to which is a row of small spots, each to an interspace. Basal to these is a scalloped line, sometimes appearing as a row of angled bars, vertices inward. A post-discal series of heavy short bars runs from costa to inner margin. The lower (inner marginal) one is very faint, occasionally almost non-existent, but the others are very heavy, and each is set on the bias, costal end inward, and more heavily so costad than elsewhere. The costal dash is basally dislocated. *Hind wing:* The marginal line, series of dots, scalloped line and cell-end bar as in the fore wing. The post-discal row of spots is heavy as in the fore wing, but quite dislocated. The two costal spots are placed inward, the next two outward, and the next four alternately inward and outward. The base of the wing is scaled with blackish. Three basal spots, one on the costa, one in the cell, and one on the

inner margin, roughly parallel to the body line. These spots, the cell-end bar and the post-discal series are all outlined faintly in white.

Female. Purer white, lacking the gray basal shading; otherwise similar to the male.

Holotype, male, Manitou, Colorado, June 5–11, 1882 (ex S. H. Scudder Coll.).

Allotype, female, same data as holotype.

Paratypes, three males, Starr Ranch, El Paso County, Colorado (6500 ft.), May 12, 1934; one male, Rock Creek, El Paso Co., Colorado (6800 ft.), May 9, 1934; one male, "Col." (ex S. H. Scudder coll.).

Holotype, allotype, and four paratypes in the collection of the Museum of Comparative Zoölogy. One paratype in the author's collection.

Remarks. This subspecies bears a rather close resemblance to the form named *violacea*[1] by Edwards. *Violacea* is represented in part in the M.C.Z., by a pair of topotypes and a series of specimens labelled "Coalb.," with various dates around 1883, all received through the Scudder collection, they having been received from Edwards. *Sidara* may be separated from these specimens by the closer proximity of the post-discal series of dashes (principally on the fore wing below) to the scalloped line. Also, in *sidara* the spots of the post-discal series of the hind wing tend to be more rounded, while in *violacea* they are either more linear (usually) or are more quadrate. In *sidara* the ground color below tends toward gray, while in *violacea* it is nearly pure white, making the white ringing of the discal and basal spots of *sidara* absent in *violacea.* A single male from Cloudcroft, New Mexico, is apparently of this subspecies, but it is less heavily marked below, and lacks the basal graying, and the subsequent white-ringing of the spots.

Lycænopsis pseudargiolus bakeri, new subspecies

UPPERSIDE:

Male. Purplish blue, nearly violet, the costal veins pencilled in whitish blue. Costa and inner margin of hind wing whitish. Both wings very narrowly bordered by a thin black line. Apical half of the outer margin of the

[1] 1866, Proc. Ent. Soc., Philadelphia, 6, p. 201. Type loc.: Kanawha River, West Virginia.

fore wing narrowly black. *Fringe* of fore wing white, becoming black towards the apex and at the vein-ends. That of the hind wing white, occasionally faintly dark at the vein-ends.

Female. *Fore wing* dark brown, with a central area of blue, of varying extent. A small streak closes the cell. *Hind wing* also brown, and with a marginal series of pale blue lunules enclosing small brown spots. *Fringe* as in the male.

UNDERSIDE:

Male. Both wings white. Markings arranged as in other *pseudargiolus* forms (see *sidara* above, for example), the marginal compound border of both wings rather faint, the post-discal, discal and basal spots very well marked, dark, and not tending to confluence. Base of hind wing tinged with greenish.

Female. As in the male.

Holotype, male, Baker, Oregon, April 20, 1941 (J. H. Baker).

Allotype, female, Durkee, Oregon, May 11, 1941 (J. H. Baker).

Paratypes, nos. 1 to 5, male, same data as holotype; nos. 6 to 10, male, Pine Creek, Baker, Oregon, May 26, 1941 (J. H. Baker); nos. 11, 12, male, Kane Creek, Oregon, March 16, 1934 (F. W. Lawrence); nos. 13, 14, male and female resp., same locality and collector as allotype, May 19, 1941.

Holotype and allotype in the Museum of Comparative Zoölogy. Two male paratypes to be returned to Mr. Baker. Remaining paratypes in the author's collection.

Remarks. Both sexes differ from the Californian race *echo*[2] in the much darker, and therefore more prominent, discal and basal spots of both wings below. The female above has slightly reduced blue areas. *Bakeri* apparently connects, to a greater or lesser degree, *echo* with *nigrescens* Fletcher,[3] from which latter it may be told in the greater amount of blue in the females and in the constancy of the underside pattern. Quoting Fletcher, "The underside of this variety (*nigrescens*) is remarkable and specimens of both sexes may be found which, if the underside alone were seen, might be referred to *neglecta*, *violacea*, *lucia* or *marginata*, and some even combine characters of all these. One beautiful form which frequently occurs, has an irregular, discal, dark blotch of confluent spots on the secondaries beneath as in

[2] 1864, Proc. Ent. Soc. Philadelphia, 2, p. 506. Type loc.: California.

[3] 1903, Trans. Roy. Soc. Canada, (2) 9, p. 213, fig'd. Type loc.: Kaslo, B.C.

lucia, and the clear marginal spots of *violacea*. This form Mr. Cockle, who has collected this butterfly for several years and has been much interested in it, considers to be most typical of the variety." In all the 16 specimens (14 of them males) of *bakeri* examined, there was but one specimen (paratype no. 8) that exhibited the slightest tendency towards the *lucia*-like confluence of spots on the underside of the hind wing, and this specimen was obviously slightly aberrant. The only indication of discal confluence was the basal thickening of the Cu_1–Cu_2, spot of the post-discal series. The further indication of aberrance was given by the thickened scalloped line of the submarginal compound border.

This subspecies is named for Mr. James H. Baker, of Baker, Oregon, from whom the majority of the specimens were received.

NEW SPECIES OF NEOPASITES WITH NOTES CONCERNING OTHERS (HYMENOPTERA, NOMADIDÆ)

BY E. GORTON LINSLEY

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Since the publication of a revision of this genus,[1] I have had the privilege of studying additional material through the kindness of Mr. J. N. Knull, Mr. P. H. Timberlake, and Prof. O. A. Stevens. The present paper includes the results of this study.

Neopasites elegans Linsley, new species

FEMALE: Form very robust; color black; abdomen deep red throughout; integument densely, coarsely punctate, moderately dull. *Head* very densely punctate, with a large patch of dense appressed white hairs around the antennal bases, a large white patch behind each eye, the two connected posteriorly along the posterior margin of the head and the latter by a narrow median line from the vertex, through the median ocellus to the antennal white patch; antennæ very dark brown, first flagellar segment about as long as following two together; upper frons and vertex coarsely, contiguously and subcontiguously punctate, punctures of ocell-ocular area at least as large as those of disk of mesoscutum; clypeus densely but more finely punctate; labrum clothed with long, dense white hair at base, surface finely punctate, indistinctly longitudinally carinate for more than two-thirds of its length; mandibles black, apices reddish. *Thorax* coarsely punctate; pronotal collar densely white pubescent, tubercles margined with white; tegulæ very dark piceous; mesoscutum coarsely densely punctate, margins and anterior three-fourths of median line, densely clothed with appressed white hairs; mesoscutellum coarsely, densely punctate, lateral margins and median line densely white pubescent, the mid line expanded at posterior margin into a subtriangular white patch; metanotum with a white patch on each side; mesepisterna coarsely, very closely, somewhat rugosely punctate, vertical face broadly margined with dense appressed white hairs; mesosternum with disk white pubescent. *Wings* lightly infuscated, veins and stigma brown. *Legs* dark brown; anterior and intermediate femora white pubescent beneath at apex, intermediate and posterior tibiæ with posterior face densely, outer face more thinly, white pubescent. *Abdomen* deep red, without any dark clouding; first tergite with a large, suboval white patch on each side bordering

[1] Linsley, E. G. 1943. A revision of the genus *Neopasites*. Trans. Amer. Ent. Soc., 69: 119–140, fig. 1.

lateral margin of basal concavity, the patches separated by nearly twice their width, basal concavity without white pubescence, tergites two to five with a large oval white patch on basal margin, the pairs separated by about their own diameters and becoming successively larger on succeeding segments except those of the fifth tergite which are smaller, tergites two and three with a latero-basal white patch on each side those of second tergite much smaller than the submedian basal patch, those of third tergite scarcely evident, tergites one to four with a lateral white patch on apical margin, that of fourth tergite small; fifth sternite bilobate, densely punctate, pubescent, apical margin broadly and shallowly emarginate.

Length 5 mm.

Holotype female (collection of Ohio State University) and one paratype, female, from El Paso County, Texas, August 30, 1940, collected by D. J. and J. N. Knull. Two additional paratypes, female, were taken by Mr. and Mrs. Knull in Culberson County, Texas, August 30, 1940. One paratype is deposited in the collection of Mr. P. H. Timberlake, another in the collection of the writer, the third in the collection of Ohio State University.

In my recent key to *Neopasites*, this species would run near *N. calliopsidis* Linsley but it is larger, more robust, with the integument duller and more coarsely and densely punctate, the fifth abdominal sternite more lobate on each side, the disk more densely punctate and hairy, and the apical margin broadly, shallowly emarginate. It further differs in the more extensive white pubescent patches of the head and thorax, the base of the labrum clothed with white hair, a slightly different pubescent pattern on the abdominal tergites, and the absence of white pubescence from the basal abdominal declivity. It is possibly the most beautifully spotted of the known species.

Neopasites knulli Linsley, new species

MALE: Form slender; color black, antennæ, mouthparts, legs, and tegulæ brownish or piceous, abdomen red; integument densely, coarsely punctate, moderately dull. *Head* very densely punctate, with a large patch of appressed white hairs around the antennal bases which is denser along the midline where it extends upward nearly to median ocellus, and a large white patch behind each eye, the two connected posteriorly along posterior margin of head; antennæ brown, distal two-thirds of flagellum reddish, first flagellar segment about as long as following two together; upper frons and vertex coarsely, contiguously and subcontiguously punctate, the punctures of ocelli-ocular area a little larger but not quite so dense as those of disk of meso-

scutum; clypeus densely but more finely punctate; labrum with a few long, erect white hairs at base, surface finely punctate, densely so at base, longitudinally carinate for about one-half its length; mandibles reddish, base and apex broadly piceous; ventral surface of head shining, area on each side of gular cavity shining, irregularly punctate, punctures averaging more than one puncture width apart. *Thorax* coarsely, very closely punctate; pronotal collar densely white pubescent, tubercles margined with white; tegulæ piceous, margins rufo-testaceous; mesoscutum densely, contiguously and more or less rugosely punctate, anterior and lateral margins and anterior half of median line clothed with traces of white hairs along lateral and posterior margins; metanotum with a white patch on each side; mesepisterna coarsely, closely, somewhat rugosely punctate, vertical face broadly margined with white. *Wings* very lightly infuscated, veins and stigma light brown. *Legs* piceous; anterior and intermediate femora apically white pubescent beneath; anterior and intermediate tibiæ thinly, posterior tibiæ more densely, white pubescent externally. *Abdomen* red; first tergite with a patch of white on each side bordering lateral margin of basal concavity, the patches separated by nearly twice their width, basal concavity without white pubescence, tergites two to five with a transverse band of white along basal margin extending from each side of middle to lateral margin, the pair on tergite two separated by about half the distance separating the patches on tergite one, those of each succeeding segment separated by about half the distance separating those of the preceding tergite, tergites two to four with a small lateral white patch on apical margin, fifth tergite with an apical fringe of white pubescence, disk faintly clouded with piceous, sixth tergite more distinctly clouded with piceous; pygidial plate ligulate, at least twice as long as broad; sternites coarsely punctate, apical margins fringed with white pubescence, last sternite with apical process truncate.

Length 5 mm.

Holotype male (collection of Ohio State University) from Culberson County, Texas, August 30, 1940, collected by D. J. and J. N. Knull.

This species is superficially very much like *Neopasites* (*Odontopasites*) *arizonicus* Linsley in size, form, and coloration, but may be distinguished by the naked eyes, less densely punctate ventral surface of the head, especially on each side of gular cavity, the short labral carina, and the darker legs and mouthparts. It appears to be more closely related to *N.* (*N.*) *minimus* Linsley, but the latter species is much smaller (3.5 mm.), with only a few scattered punctures on the under side of the head, and the labrum is not carinate.

Neopasites robertsoni Crawford

Among material recently submitted by Prof. O. A. Stevens for study were examples of this species from Hatton, North Dakota, August 3 (Stevens).

Neopasites stevensi (Crawford)

This species was also taken by Prof. Stevens at Hatton, North Dakota, on August 3, visiting flowers of *Grindelia squarrosa*.

Neopasites heliopsis (Robertson)

N. heliopsis was recently recorded[1] from Winnecock, North Dakota. The locality should have read Winnecook, Montana. The record was based on a specimen in the collection of P. H. Timberlake.

Neopasites calliopsidis Linsley

This species has been previously recorded from Iowa, Kansas and Montana. Mr. Timberlake has submitted specimens from the following localities in Colorado: Boulder County, July 6, 1925 (C. H. Hicks); Boulder, June 26 and 28, 1939, on *Chrysopsis* (Timberlake); Boulder, 2 miles north, June 25, 1939, on *Chrysopsis* (Timberlake); and Cuchara Camps, Spanish Peaks, elevation 8000 ft., July 4, 1939, on *Aster* (Timberlake). In these specimens the average extent of the black areas on the abdomen is greater than in the type series (Iowa), and some males also have the basal white spots of the tergites confluent on each side.

THE DEATH-FEINTS OF ALOBATES PENNSYLVANICA DeG., AND ALOBATES BARBATA KNOCH.

BY HARRY B. WEISS

Hibernating specimens of both species of darkling beetles were tested during the last week of April, 1944, in order to determine the duration of their death-feints. All specimens were kept at a room temperature of 72° F., several days before testing in order to fully bring them out of hibernation. Death-feints occurred when they were picked up or when they were pressed gently, ventrally or when dropped through a distance of six or twelve inches. Some beetles required a lot of handling and others very little in order to bring on the death-feint. The ventral surface of the thorax appeared to be the most sensitive area. When the stimulus was applied to the dorsal surface the death-feint did not occur. It was impossible to apply the stimulus with equal force each time when it was done by hand, and it is not known if there is any connection between the force of the stimulus and the duration of the reaction. However, it does not seem likely that there is, in view of the fact that a gentle stimulus was just as liable to promote a long or short death-feint as a hard stimulus. Although different degrees of pressure and different amounts of handling were required to initiate the death-feints, both the sensitivity of the individual and the duration of its reaction probably depend upon the variable organization of its nervous and motor mechanism.

Alobates pennsylvanica DeG.

Ten specimens of this species were induced to feign death at Fahrenheit temperatures of 72° and 82°. The durations of the death-feints are shown in the following table. Some beetles rested dorsally and others ventrally during the death-feint, but neither position appeared to affect the duration of the reaction.

Successive death-feints in the same beetle became progressively, irregularly shorter. One beetle refused to react after the eight-

DURATION OF DEATH-FEINT

Beetle	At 72° F. April 19	At 82° F. April 26
	Seconds	*Seconds*
A	778	394
B	266	105
C	62	24
D	138	262
E	247	520
F	43	230
G	129	173
H	1,095	160
I	35	620
J	1,851	380
Average	464.4	268.8

eenth successive death-feint; another after the sixth, and many of them after the third or fourth.

Alobates barbata Knoch.

The durations of the death-feints of ten specimens of this species at Fahrenheit temperatures of 72° and 84° are shown as follows:

DURATION OF DEATH-FEINT

Beetle	At 72° F. April 20	At 72° F. April 25	At 84° F. April 25
	Seconds	*Seconds*	*Seconds*
A	163	25	48
B	165	306	35
C	6	406	86
D	30	40	180
E	227	213	15
F	414	152	265
G	340	85	154
H	97	41	92
I	76	56	7
J	315	475	20
Average	183.6	179.9	90.0

Successive death-feints in the same beetle of this species were generally similar to those reported for *Alobates pennsylvanica*.

Both species reacted alike except for the fact that the death-feints of *A. pennsylvanica* endured longer than those of *A. barbata*. When the temperature was increased 10 or 12 degrees the average duration of the reaction declined approximately one-half, for both species.

Apparently there is a variation in the sensitivity of different individuals, to the external stimuli initiating the death-feint and also in the period of recovery. These variations are probably due to differences in the quality of the labile compounds in the receptive and conductive parts of the nervous system and in the contractile muscle tissue. The destructive chemical action involved in the reaction to the stimulus and the restoration of the discomposed substances require different periods of time for different individuals. A high temperature apparently hastens recovery. It would be of interest to know if internal stimuli play any part in the restorative processes.

INSECT FOOD HABIT RATIOS OF NEW YORK STATE

By Harry B. Weiss

At various times during the past 15 years I have wondered if a food habit classification of the species of insects recorded from New York would show ratios that differed materially from those of other sections such as New Jersey, Connecticut, etc. In order to satisfy my curiosity, I finally classified according to their family food habits 15,343 of the 15,449 species recorded in "A List of the Insects of New York," M. D. Leonard, Editor-in-Chief, that was published January, 1928, as Memoir 101 of the Cornell University Agricultural Experiment Station. The Anoplura, Mallophaga and Siphonaptera were omitted because of their non-relation to vegetation or to other insects, likewise a few other species, difficult to classify. Considering the large number of species involved, these omissions are relatively unimportant.

The difficulty of classifying families of insects in accordance with the food habits of their members is fully appreciated and the weaknesses of such a classification have been admitted in a former paper.[1] The terms saprophagous, phytophagous, etc., are used in their broadest sense and I am aware that such conclusions as may be drawn from food habit classifications are broad generalizations.

[1] Insect Food Habit Ratios of North Carolina and Mount Desert Island, Maine. Jour. N. Y. Ent. Soc., vol. 47, p. 155–157, June 1939.

The following table shows the distribution ratios of food habit types for New York and, for comparative purposes, the ratios for five other large areas are included. Five of the six areas are large and embrace a variety of vegetation. Under such conditions one would not expect the distribution ratios of the types of food habits to vary widely and it will be noted that the New York ratios are not unlike those for other areas.

	No. species	Phyto-phagous	Sapro-phagous	Harpacto-phagous	Para-sitic	Pollen feeders, etc.
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Western Arctic Coast, N. A.	400	47	27	14	10	2
New Jersey	10,500	49	19	16	12	4
Connecticut	6,781	52	19	16	10	3
North Carolina	9,249	46	17	22	11	4
Mount Desert Island, Me.	5,177	52	17	14	15	2
New York	15,343	48	23	17	10	2

In former papers it was brought out that in relatively small areas, each with a uniform type of vegetation, the ratios of the types of food habits, based on the species present, varied in accordance with the type of vegetation, if the numerical ratios between the species and the factors tending to reduce their numbers are considered as constant. In large areas such as are indicated in the table, the ratios appear to vary but little.

Although the food classifications in the table are broad generalizations of "apparent" food, comparatively little has been added to our knowledge of "actual" food, since B. P. Uvarov called attention in 1928 ("Insect Nutrition and Metabolism," Trans. Ent. Soc. London, Dec. 31, 1928), to the limited number of cases where the true food of insects was actually known.

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THE STRUCTURE OF LIVING INSECT NERVES AND NERVE SHEATHS AS DEDUCED FROM THE OPTICAL PROPERTIES[1]

BY A. GLENN RICHARDS, JR.

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In a previous issue of this JOURNAL relatively indirect histochemical data were presented and were interpreted as indicating the presence of lipid nerve sheaths in insects (Richards, 1943). These sheaths, like those of so-called non-myelinated nerve fibers of vertebrates, are extremely thin and are very labile under the influence of fixation techniques. Optical studies with polarized light permit the study of living nerves and so obviate the difficulties attendant upon histological fixation. They also give far greater sensitivity. The present paper presents data on the ultrastructure of normal living insect nerves and nerve cords as deduced from optical data.[2] The presence of lipo-protein nerve sheaths in insects is confirmed and amplified.

The studies reported herein were performed on the nervous system of adult American cockroaches, *Periplaneta americana*, and on larvæ of the house mosquito, *Culex pipiens*. Most of the studies were made on intact nerve cords and peripheral nerves

[1] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the University of Pennsylvania.

[2] Thanks are due to Dr. R. S. Bear and Dr. F. O. Schmitt, of the Massachusetts Institute of Technology, for assisting the author with the use and interpretation of polarized light data, and to Dr. H. B. Steinbach, of Washington University, for the loan of a Köhler compensator.

but the data so obtained agree with studies on teased, single-fiber preparations of the larger nerves of cockroaches. Observations were also made on single specimens of an assortment of other arthropods to see if similar optical properties occur for nerves throughout the phylum Arthropoda.

THE USE OF POLARIZED LIGHT

From the viewpoint of optics a nerve is composed of optically inactive components and several types of optically active components. In studies on nerves polarized light is used to determine (in living or fixed nerves) the presence and status of the oriented optically active components. One can in a sense fractionate an intact nerve, and with a knowledge of the optical activities of the extractable components determine where the various components are located and what their orientation is in a living nerve. In experimental studies polarized light can be used to look for degradations of either orientation or chemical structure. One is dealing, then, with a kind of cytological inspection but with a method of inspection that is extremely sensitive when used for nerve studies.

No detailed treatment of the use and interpretation of polarized light data can be given here. Some of the terms to be used in this paper may be mentioned in relatively non-technical language but for an understanding of the complex phenomena involved reference must be made to the extensive treatises listed below.[3]

An ordinary beam of light is considered as a series of wave motions in which the light rays vibrate in all planes *perpendicular* to the direction of propagation. *Plane polarized light* is light in which the vibrations are all in the same plane[4] (Fig. 1). As

[3] Descriptions of the instruments and general phenomena can be found in Rogers & Kerr (1933) and other textbooks on mineralogy and optics, especially Ambronn & Frey (1926). Excellent diagrams of the optical phenomena involved are given by Myers (1938). The most lucid elementary presentation for beginners is perhaps that of Cheshire (1932). For the interpretation of biological data see W. J. Schmidt (1937) and Frey-Wyssling (1938). A more recent and comprehensive analysis of the optical phenomena shown by nerve sheaths is given by F. O. Schmitt & R. S. Bear (1939).

[4] Actually a light wave consists of electrical and magnetic vectors which vibrate in mutually perpendicular planes perpendicular to the direction of

such, plane polarized light is analogous to parallel waves on water, where the waves vibrate up and down in one plane while traveling forward. With polarized light one studies the *birefringence* (= double refraction) of a material. This is accomplished by observing the specimen between crossed Nicol prisms or other

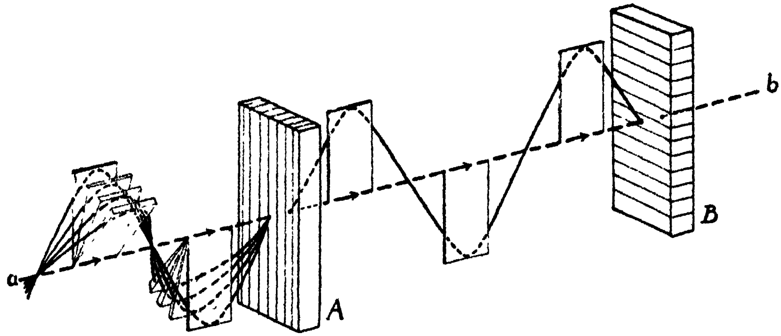


FIG. 1. Diagram of the effect of polarizing blocks set with the polarizing planes at a 90° angle. The axes of the polarizing blocks is indicated diagrammatically by parallel lines. The planes in which the light rays vibrate are sketched in for clarity of three-dimensional visualization.

A light beam traveling along the dotted line in the direction $a \longrightarrow b$ is composed of waves vibrating in all axes perpendicular to the direction of propagation (four of these planes are drawn in this diagram). On passing through the polarizer *A* only waves vibrating in the plane of the paper are transmitted. On reaching the polarizer *B*, set at a 90° angle, these are just the waves that are completely extinguished, and therefore no light is transmitted beyond *B*.*

polarizing materials,[5] *i.e.*, one prism is below the object and transmits only light that is polarized in one particular plane, the other prism is above the object and being set at a right angle to the

propagation, but in polarized light studies it is customary to designate the vibration plane of the electrical vector as the plane of polarization.

[5] For a good diagram of how Nicol prisms function see Myers (1938), figure 84. The same result is obtained by a different principle in "Polaroid" sheets, etc.

* For clarity of diagrammatic presentation the author has taken some liberties with optics in Figures 1 and 2. Actually, four waves traveling in phase along one line would combine into a single wave of intermediate position and the sum of the four in height. For illustrating the point in question the method used here seems clearest even though technically different vibration planes should be drawn along different lines parallel to *a–b*.

first eliminates all of the light except that which has had its plane of polarization changed by passing through the specimen (Figs. 1–2). The ability to change the plane of polarization at certain orientations is a property of birefringent materials. Substances which show birefringence are said to be *anisotropic,* substances which do not are called *isotropic.* Even with anisotropic substances, however, there is one direction along which light (ordinary or polarized) is unaltered; this is termed the *optic axis* of the substance. The optic axis may be called isotropic, all other axes are anisotropic. The anisotropic axes have the property of changing the plane of polarization by splitting any transmitted beam of light into two rays[6] which vibrate in mutually perpendicular planes (Fig. 2) and travel with different velocities.[7] The optical effects can be completely described diagrammatically in terms of a direction of vibration for faster (or slower) transmission (see below) and two *refractive indices,* since the refractive index is an inverse statement of the relative speed of light. Substances with only one refractive index are called isotropic, substances with two different refractive indices are called *uniaxially anisotropic,* and substances with different refractive indices for all three vibration planes of rays perpendicular to the optic axis are called *biaxially anisotropic.* Most biological anisotropic substances, including those dealt with in this paper, are uniaxial.

Several kinds of birefringence are shown by biological materials. In addition to uniaxial and biaxial anisotropy, birefringence may be either *positive* or *negative* with respect to a particular direction. These are arbitrary terms applied to differentiate between materials in which the index of refraction is greater

[6] Commonly called the *ordinary* and *extraordinary rays.*

[7] As Cheshire (1932) points out, birefringent substances include fibrous and crystalline structures where the orientations of the components are such that the structure is different in the longitudinal and transverse directions. In a certain sense the structure is analogous to the grain of wood, and, as Tyndall showed, the speed of heat and sound waves is different for waves traveling along the long axis of a piece of wood and for waves traveling perpendicular to this. With birefringent materials and polarized light we have similar differences in speeds in different directions with the additional complication that both the ray direction and the vibration direction are concerned.

for the vibration in the stated direction than for the other vibration perpendicular to it (*positive birefringence*), and materials in which the relative velocities are the reverse (*negative birefringence*). The direction for faster (or slower) vibration is determined by comparing the effect with a known standard. Commonly one takes advantage of interference effects for this purpose and uses a gypsum plate which makes the entire field appear red. Any effect of the specimen must be either additive or subtractive, and reference to Newton's series of colors shows which it is. Knowing the orientation of the various parts of the system one

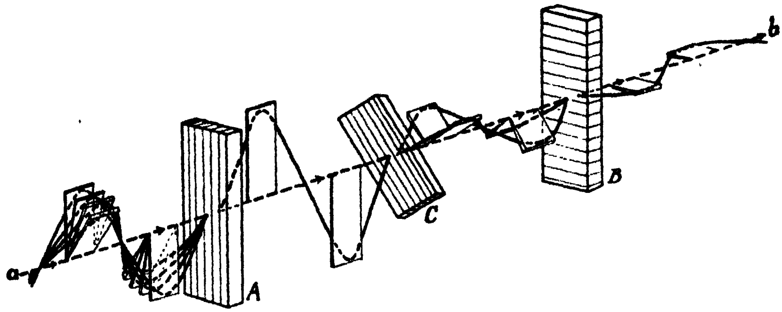


FIG. 2. Same as Figure 1 but with a sheet of birefringent material (the specimen, *C*) inserted between the polarizers with its axis at a 45° angle to each. The description is the same as for Figure 1 except that the specimen, *C*, oriented at a 45° angle splits the plane polarized beam into two mutually perpendicular waves vibrating at a 45° angle to the beam from *A* to *C*, and therefore at a 45° angle to polarizer *B*. The waves do not reach *B* at a 90° angle to the vibration direction, and therefore light is transmitted. Adding to these figures the parts of a compound microscope will give a crude diagram of the optics of a polarizing microscope of the orthoscope type.

can usually tell by clear-cut color changes (from red to blue or yellow) whether the substance is positively or negatively birefringent.

The terms positive and negative birefringence, however, can be used in either of two ways: 1) When the orientation of the optic axes of the anisotropic substance is known, then the material may itself be called either positive or negative depending on whether the index for vibrations parallel to the optic axis is greater or less, respectively, than the index for vibrations perpendicular to this axis. 2) Whether the orientation of the optic

axes is known or not, one can refer to an anatomical structure as positive or negative with respect to some distinguishing direction. In many cases in biology the optic axis of the oriented birefringent material coincides with the long axis of the gross structure (*e.g.*, muscle, tendon, axis cylinder of nerves, etc.). Thus a muscle fiber is positively uniaxial in relation to both its long axis and the optic axes of the anisotropic micelles. In the case of the nerve sheath, however, the anisotropic micelles are oriented with their optic axes radial (perpendicular to the long axis of the nerve). Accordingly, the nerve sheath can be called either positive or negative depending on whether the reference direction is the optic axes of the anisotropic particles or the long axis of the nerve. This can be confusing unless one is careful to note the reference direction, especially as whichever reference direction is chosen some nerve sheaths are positive and some negative in relation to it. In biological literature reference has usually been made to the anatomically long dimension, and this custom is followed in the present paper; however in the recent review by Schmitt & Bear (1939) these authors have shifted to employing the optic axes as reference directions.

Birefringence may be produced by either the internal structure of a molecule or its asymmetrical shape. The first is called *intrinsic birefringence,* the second is called *form birefringence.* Distinguishing between these two types is quite useful in analyzing the source of the observed birefringence. Fortunately this is readily accomplished. Form birefringence is due to the presence of oriented submicroscopic rodlets or plates called *micelles;* immersion of these micelles in a medium of the same refractive index abolishes their birefringence but has no effect on any intrinsic birefringence that may be present. By immersion in media of various refractive indices one can then determine not only whether the material possesses any intrinsic birefringence but more importantly whether there is present a second birefringent material that is normally masked by the form birefringence of the first material. Thus, in a so-called non-myelinated nerve one first observes a birefringence that is positive in relation to the long axis of the nerve. If such a nerve is immersed in a salt solution containing glycerine, the sign of birefringence is reversed. But if the nerve is first extracted with alcohol the sign

cannot be reversed. This is interpreted as due to the positive form birefringence of the oriented protein normally masking the negative intrinsic birefringence of the lipids (Schmitt & Bear, 1937).

In treating birefringence quantitatively, certain values can be measured and others calculated from these measurements. Properly oriented anisotropic substances split a beam into two rays which, vibrating in different planes, travel through the specimen at different velocities. Obviously, if one of the component rays travels more slowly, it will lag behind and emerge from the specimen a certain finite distance behind the faster ray.[8] This difference is called the *retardation* (= phase difference, = amplitude, ϕ). With a Köhler compensator the retardation is calculated from the angle between the compensator plate and the specimen necessary to compensate for (abolish) the retardation of the specimen:

$$\phi = -\ m\lambda \sin 2\beta_1, \text{ or} \tag{1}$$

$$\phi = -2m\lambda \sin 2\beta_2, \tag{2}$$

where m is the known maximum retardation of the compensator plate, λ the wave length of light (551 mμ is taken as the "center of gravity" of white light), and β_1 and β_2 the measured angles using the Köhler method and the Bear & Schmitt modification respectively (Bear & Schmitt, 1936b). The sign of ϕ will depend on whether β_1 and β_2 are additive or subtractive angles and will agree with the qualitative determination of the birefringence as positive or negative in character.

Obviously, the amount the slower ray is behind the faster ray will depend on both the difference in velocity and the thickness of the specimen being measured. The difference between the two velocities, called the *magnitude of birefringence*, is the fundamental property we are interested in obtaining. With sheets of known composition and orientation the magnitude of birefringence is readily calculated from:

$$n_1 - n_2 = \frac{\phi}{d} \tag{3}$$

[8] This actually transforms the plane polarized beam of light into an elliptically or circularly polarized beam. However, for our purposes we can continue to treat it as though we were dealing with two plane polarized beams vibrating perpendicular to one another.

where n_1 and n_2 are the two refractive indices, ϕ the retardation, and d the thickness of the specimen.

In nerve studies it is relatively easy to determine the retardation (ϕ) but sometimes difficult to obtain the true effective distance (d). This is partly due to the heterogeneous nature of nerves, and in the case of nerve sheaths partly to the complication introduced by the optic axes of the sheath micelles being oriented radially. Schmitt & Bear (1937) have derived the following equation to allow for the radial orientation of the sheath micelles:

$$n_1 - n_2 = \frac{9.46 \sin 2\beta_2}{(d_1 + 2d_2) \cos^{-1}\left(\frac{d_1 + 2d_2}{3d_1}\right)} \tag{4}$$

where n_1 and n_2 are the two refractive indices, β_2 the compensation angle determined by the Bear & Schmitt method, d_1 the axon diameter or its equivalent, and d_2 the axis cylinder diameter or its equivalent.

For entire insect nerve cords none of these methods for determining the magnitude of birefringence seems satisfactory. Due to the low amplitude it has not been found feasible to attempt quantitative measurements on teased single nerve fibers of insects except for extracted nerve sheaths and the axis cylinder of stretched nerves. Equation (1) has been used for the points plotted in Figure 3[9] but equations (3) and (4) have been applied to estimate the more fundamental birefringence values for single fiber preparations and for the neural lamella surrounding the nerve cord.

For the work reported in this paper a Leitz polarizing microscope was used, employing orthoscopic methods, white light, various magnifications and several types of compensators. Quantitative measurements were made with a Köhler $\lambda/20$ rotating mica plate compensator (Leitz Wetzlar No. 2335) using both the Köhler and the Bear & Schmitt methods (Bear & Schmitt, 1936b).

THE OPTICAL EFFECTS SHOWN BY INSECT NERVES

1. *General*

Until recently insect nerves have been considered non-myelin-

[9] So far as graphs such as figure 3 are concerned, the same curve would be obtained from using the angle (β), the retardation (ϕ) and the magnitude of birefringence ($n_1 - n_2$).

ated (Richards, 1943). In many insects (*e.g.*, mosquito larvæ) single nerves are extremely small (less than 2 μ in diameter) but in the large cockroaches some single fibers attain a diameter of 10 μ and a few are 20–30 μ in diameter. The thicknesses of the nerve sheaths are apparently not more than a few per cent of the fiber diameter. One can recognize the sheath and estimate its thickness around single nerve fibers of the cockroach, but the sheath around nerves of mosquito larvæ is beyond resolution with ordinary microscopical methods.

It is relatively easy to tease out and identify for study single fibers from a cockroach nerve cord. Many observations can be made satisfactorily, however, on intact nerve cords containing many nerves in one bundle. The intact interganglionic abdominal connectives in the adult American cockroach have a diameter of 175–280 μ, while those of fourth (last) instar mosquito larvæ are only 13–24 μ in diameter.

Around the outside of the intact nerve cord there is a secreted sheet of material which Scharrer (1939) has termed the neural lamella. This sheet is also birefringent but does not intefere with optical analyses of the included nerves. It will be discussed in a separate section.

In analyzing nerves, they are first examined in a salt solution, with or without previous fixation, then they may be examined in glycerine or other media of high refractive index to mask the form birefringence and so determine what intrinsic birefringence is present. In insect nerves such immersion normally results in a reversal of the sign of birefringence, indicating that in a normal nerve we are dealing with a balance between birefringent materials of opposite sign (curve 2, Fig. 3). The lipids may be removed by appropriate solvents (*e.g.*, alcohol); comparison of the optical properties before and after extraction permit both showing and localizing the presence of the optically active lipids. Since the form birefringence of the proteins normally predominates in non-myelinated nerves, it is ordinarily sufficient to examine a preparation in salt solution and then in a dilute solution of glycerine in saline solution. For some special purposes and for evaluating the method other media, solvents and variations of technique may be used.

2. *Analysis of the Birefringent Properties of the Axis Cylinder*

Intact, living ventral nerve cords and larger peripheral nerves of American cockroach adults and mosquito larvæ immersed in saline solutions[10] show a slight birefringence which is usually positive in relation to the long axis of the nerve fibers (Fig. 14).[11] The birefringence of the axis cylinder[12] of living cockroach nerves in salt solution or of fixed cockroach nerves after lipid extraction is relatively diffuse, is positive in relation to the nerve axis and seems to be fairly homogeneous throughout *single* giant nerve fibers. In the normal relaxed condition the amplitude of birefringence (ϕ) due to the axis cylinder is very small but it can be increased greatly by tension. Cockroach nerve cords fixed in formol-saline solutions in a *relaxed* condition, then teased to give single-fiber preparations, extracted with alcohol (to remove masking lipids) and examined in water, show bright positively birefringent lines for the sheaths but only faint positive birefringence for the axis cylinder (Fig. 5). Similar results are obtained for the axis cylinder with living cockroach nerve cords teased and examined in salt solutions. In contrast, cockroach nerve cords fixed in formol-saline solutions in a *stretched* condition (1½ times the relaxed length) and then teased and treated as above show strong positive birefringence throughout single fiber preparations (Figs. 8–10). Measurements of the amplitude of birefringence show that the birefringence of the sheaths is affected relatively little (perhaps not at all) by the stretching but that the birefringence of the axis cylinder is greatly increased. Immersion in glycerine practically abolishes the birefringence of the axis cylinder showing that this is due mainly to anisodiametric micelles exhibiting form birefringence.

10 For cockroach adults the salt solution used contained NaCl 10.93, KCl 1.57, $CaCl_2$ 0.85, $MgCl_2$ 0.17 and $NaHCO_3$ 0.17 grams per liter; for mosquito larvæ NaCl 7.8, KCl 0.62, $CaCl_2$ 0.40 and $NaHCO_3$ 0.17 grams per liter.

11 Occasionally a normal relaxed nerve cord is found to be negative in saline. Such nerve cords can be reversed to positive by stretching. Naturally, immersion in glycerine-saline does not reverse the sign of birefringence of such a nerve cord; it only increases the negativity. See curve 3, Figure 3.

12 The axis cylinder is the nerve axon exclusive of its surrounding membrane and sheath.

Whatever the nature of the tension effect may be,[13] the fact remains that the axis cylinder of insect nerves contains anisotropic micelles, presumably protein, with at least a predominant orientation in the direction of the long axis of the nerve (Fig. 4).

The studies on single-fiber preparations from cockroaches are in agreement with observations on intact nerve cords and peripheral nerves. In intact nerve cords it is easy to measure the total birefringence but the superposition of many fibers makes it difficult to determine what components of the birefringence are due to the axis cylinder and what to the nerve sheaths. In general, a longitudinally striated appearance to the birefringence of intact nerve cords can be interpreted as indicating nerve sheath components whereas the more homogeneous birefringence seen in stretched nerve cords can be interpreted as being due to the summation of sheaths and stretched axis cylinder effects.

An analysis of the form factor involved in this birefringence is graphed in Figure 3. Since the measurements were all made with intact nerve cords these curves, of necessity, show a summation of axis cylinder and sheath effects. Curve 1 shows the change in amplitude with change in refractive index of the immersion media for relaxed nerve cords from which the lipids have been removed by extraction with alcohol and ether. This curve shows that most of the birefringence of lipid-extracted nerves is due to micellar form, the micelles having a refractive index between 1.56 and 1.60 when determined in this manner. A small residue of intrinsic birefringence is probably also present since the value never falls quite to zero.[14] Comparison of these data

[13] There are several conceivable explanations of the increase of birefringence of the axis cylinder on stretching. Mihalik (1937) has made a similar report for vertebrate nerves. The phenomenon is being studied further. It is presented here only because the birefringence of the axis cylinder of insect nerves can be seen most clearly in stretched nerves.

[14] This is the interpretation accepted by Schmitt and Bear. The Ambronn immersion technique commonly encounters difficulties with biological materials. Theoretically curve 1 should be symmetrical. Correction for the shrinkage that occurs in media of higher refractive index is not sufficient to make these curves symmetrical. Such slight asymmetry is seen in various published curves (*e.g.*, Chinn & Schmitt, 1937, Fischer, 1944). Different methods of fixation give roughly parallel curves of considerably different height (Bear, Schmitt & Young, 1937b). Curve 1 and 2 of the present paper

with the data from single-fiber preparations suggests that the form birefringence plotted in curve 1 is due to both the axis cylinders and the nerve sheaths but how much is contributed by each of these components has not yet been determined. Curve 2 shows the change in amplitude of a formalin-fixed nerve cord immersed in media of increasing refractive index with reversal of sign at approximately 1.343. Curve 2 is typical for normal cockroach nerves. Theoretically one would expect this curve to parallel curve 1 if a series of non-lipid-solvent immersion media of higher refractive index were available. Curve 3 gives data from a similar immersion series for one of the occasional nerve cords which is already negative in saline. Great variation, such as is shown by the difference between curves 2 and 3, occurs between different preparations. This seems, at least in part, due to tension, and will be discussed in a subsequent paper.

It does not seem feasible to attempt estimating the true magnitude of birefringence $(n_1 - n_2)$ from measurements on entire nerve cords. Estimates from formalin-fixed, alcohol-extracted, single-fiber preparations of the cockroach using equations (1) and (3) indicate that the magnitude of birefringence of the axis

and similar curves by Chinn (1938) though roughly parallel are not so far apart as one would expect. More serious is the great variation of curves for some materials depending on the immersion series employed. Castle (1936) has treated in some detail the radically different types of curves shown by chitin in different series of immersion media where imbibition and possibly adsorption alter the picture and complicate interpretation. The use of different series of immersion media has given only slight differences for nerve sheaths (Chinn & Schmitt, 1937) but a much lower value for the refractive index is assumed from glycerine-immersion series in the recent paper by Werndle & Taylor (1943). The complex phenomena involved in these unexpected variations are not understood. Castle (1936) feels that the situation is so complex that it defies explanation at present, and that the immersion method is not valid for the determination of the refractive index of certain materials such as chitin. The curves from nerves and nerve sheaths by various methods and media are, however, sufficiently consistent to be reasonably certain that (1) insect nerves are similar to other nerves, and (2) that the protein component shows largely a form birefringence and that it is of opposite sign from the lipid birefringence. Under the circumstances it seems that the best proof of the lipo-protein nature of the nerve sheaths comes from the results of extraction experiments rather than from the immersion curves (metatropic effect).

cylinder ranges from nearly zero (immeasurably low) in relaxed nerves to approximately 0.0018 for stretched nerves.[12] The several possible reasons for low magnitudes in axis cylinders are discussed by Bear, Schmitt & Young (1937b) and Richards, Steinbach & Anderson (1943).

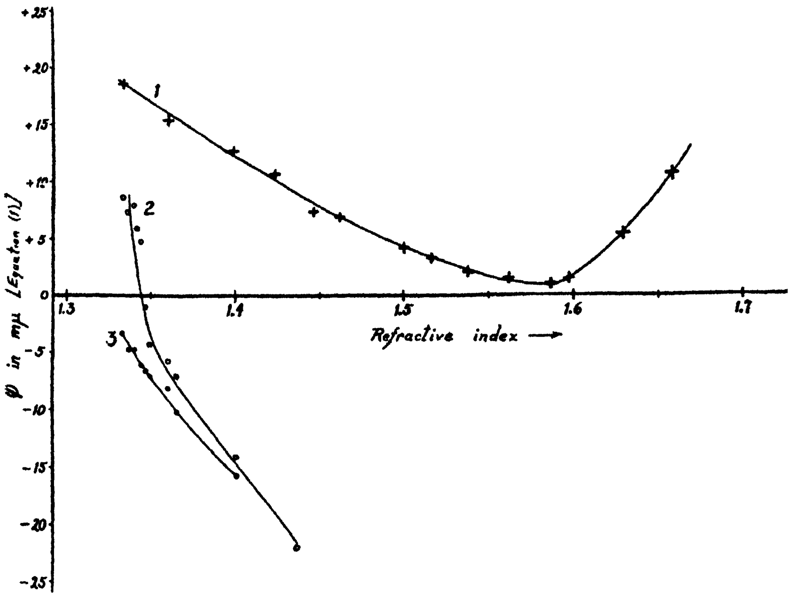


FIG. 3. Data from immersion experiments with cockroach nerve cords. Entire interganglionic connectives were used; the measurements accordingly represent the summation of effects shown by a large bundle of nerves. Curve 1 gives the averages from measurements on six nerve cords fixed in 95% ethyl alcohol and subsequently measured in media ranging from 1.331 to 1.659 in refractive index,* with corrections being made for differences in size and for shrinkage in some of the media. Curve 2 gives the readings from a formalin-fixed nerve cord immersed in distilled water and a series of increasing concentrations of glycerine, range 1.333 to 1.435 in refractive index. This curve closely approximates the typical picture for fresh nerves in saline, with reversal of sign occurring at a glycerine concentration between 10 and 15%. Curve 3 gives measurements from one of the few formalin-fixed nerves which was found to be negative in water.

* The immersion media used were: methyl alcohol, ethyl alcohol, 1-nitropropane, methylcyclohexane, chloroform, carbon tetrachloride, benzene, dimethyl phthalate, methyl salicylate, anethole, aniline, bromoform, carbon bisulfide and alpha-bromo-naphthalene.

The nerve cords of mosquito larvæ are much smaller than those of cockroaches, and the included nerves are all very small (< 1 to $2\ \mu$). All studies on mosquito nerves were made with intact nerve cords since satisfactory single-fiber preparations were not obtained. The intact living nerve cord in appropriate salt solution, like that of the cockroach, is positively birefringent in relation to its long axis. In the relaxed condition (Fig. 14) it shows a more or less striated birefringence which, as noted above, is interpreted as indicating the presence of a relatively strongly birefringent sheath component. In the stretched condition the birefringence is stronger and nearly homogeneous. By comparison with cockroach nerves, this is interpreted as indicating an increase of the axis cylinder component of birefringence. The data from mosquito nerve cords are consistent with the idea that they have qualitatively the same configuration as is found in cockroach nerves, but they are very small and the amplitude of birefringence is very low.[15]

There is no reason to think that the ultrastructure of the axis cylinder of insect nerves is different from that of nerves of other animals. The amplitude of birefringence of relaxed insect nerves is unusually low but this may possibly be reconciled by further study. Otherwise, the picture recorded above agrees well with reports by various workers on various nerves (see W. J. Schmidt, 1937). The birefringence of the axis cylinder is due to anisotropic protein micelles showing chiefly a form birefringence (anisodiametric particles). These micelles are oriented or at least predominantly oriented with their optic axes parallel to the long axis of the nerve since the axis cylinder is isotropic in cross section. Their birefringence is positive both with respect to their optic axes and to the nerve axis (Fig. 4). As already reported with other nerves, there is a slight reduction in the amplitude of birefringence on histological fixation. There is a rapid decay or loss of birefringence of the axis cylinder follow-

[15] The phase retardation (ϕ) of an entire, relaxed, $18\ \mu$, interganglionic connective of a mosquito larva in saline as calculated from equation (1) is of the order of only 2–3 $m\mu$. In a stretched nerve cord this may rise to 6–8 $m\mu$. These values compare favorably with values given for cultured Corethra nerves by Pfeiffer (1943).

ing mechanical injury, the action of certain venoms and insecticides, and attending post-mortem degeneration.[16]

3. *Analysis of the Birefringent Properties of the Nerve Sheaths*

Insect nerve sheaths are relatively thin. In the largest nerves of the cockroach they attain a thickness of only a little more than one micron, *i.e.*, they are only a few per cent of the fiber diameter. In smaller nerves they seem to be proportionately thinner, and in the smallest cockroach nerves and in all nerves of mosquito larvæ they are too thin for direct observation (submicroscopic thickness). Due to the thinness of these sheaths it is difficult to determine for certain whether or not they are produced by distinct sheath cells. However, in longitudinal sections of insect nerve cords one can find a few nuclei between the nerve fibers.[17] Bear, Schmitt & Young (1937a) concluded that nuclei found around squid giant nerve fibers probably represented cells analogous to the Schwann cells of vertebrate nerves. Possibly the nuclei seen in insect nerve cords likewise represent sheath cells analogous to Schwann cells.

These thin nerve sheaths are metatropic, *i.e.*, they exhibit a weak positive birefringence (in relation to the nerve axis) which is readily reversed to negative by immersion in media of slightly higher refractive index (curve 2, Fig. 3). These data can be interpreted in the same manner that similar data from other animal groups have been interpreted by Schmitt & Bear (1937, 1939). The individual nerve sheaths are composed of bound layers of protein and lipid, both of which are birefringent but of opposite sign. The protein normally dominates slightly with its form birefringence. Masking the form birefringence of the protein with glycerine permits the intrinsic lipid birefringence to be seen. Removal of the lipids with appropriate solvents (*e.g.*, alcohol) increases the positive birefringence and makes it impossible to reverse the sign of birefringence with glycerine. Since two oppositely birefringent compounds can be thus demonstrated

[16] A presentation of some of the degenerative effects due to venoms and insecticides will be given in subsequent papers.

[17] Other than those associated with tracheæ.

and identified (Figs. 5 vs. 11, 14 vs. 15), it follows that normally both are present in the sheath, and that the normal sheath birefringence is a picture of how much one component (in this case protein) predominates in birefringence over the other.

The axis cylinder viewed from the side is birefringent throughout. The nerve sheaths, however, show birefringence only at or very near to the edges of the nerve. This is due to the manner of orientation of the optic axes of the anisotropic micelles. In all birefringent materials and structures there is one axis, the optic

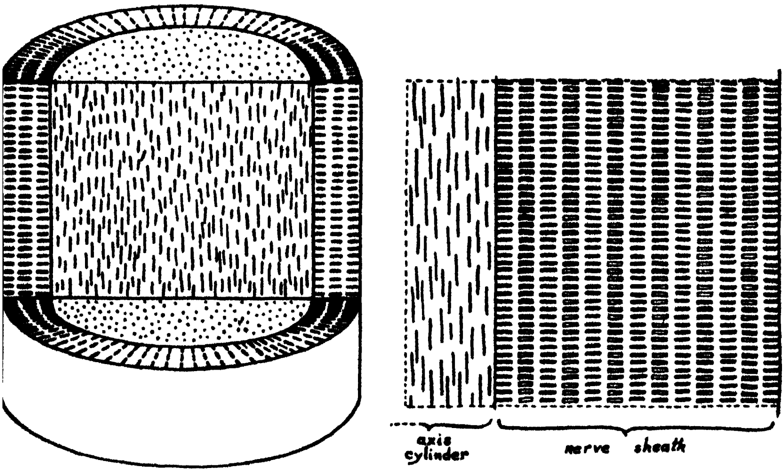


FIG. 4. A diagrammatic representation of the orientation of the birefringent micelles in a nerve and its sheath. The long axes of the rodlets in these diagrams is used to indicate the orientation of the optic axes of the micelles. On the left is a hemi-section of a nerve showing the micelles of the axis cylinder oriented longitudinally while those of the sheath are oriented radially. On the right is an enlarged sketch showing the arrangement of bound lipid and protein micelles in concentric layers as suggested by Schmitt, Bear & Palmer (1941).

axis, along which the structure is isotropic. In the nerve sheaths both the protein and lipid molecules must be oriented with their optic axes arranged radially (Fig. 4). With such an arrangement, the central part of the sheath should appear isotropic, as it does, since the optic axes of the micelles lie in the axis of the microscope, whereas the edges should be strongly birefringent, as they are. This is confirmed by observation of negative polariza-

tion crosses observed in cross sections of alcohol-extracted giant cockroach nerves (compare Chinn & Schmitt, 1937).

The magnitude of birefringence ($n_1 - n_2$) for the sheath can be calculated approximately from measurements on single giant fibers of cockroaches. Fresh nerves in saline show only extremely faint sheath birefringence. This indicates that the balance of birefringence from the protein and lipid (opposite signs) is nearly equal, and the magnitude of birefringence of the combination is therefore nearly zero. Alcohol-extracted nerves (Figs. 5–7) should show only the protein component. The average of measurements on eleven alcohol-extracted nerves ranging from 6 to 10 μ in diameter using equation (4) is the extremely low value of $n_1 - n_2 = 0.0016$. This represents the value for sheath protein; the lipid value must be similar but slightly lower.

The nerve cords of mosquito larvæ show the metatropic reversal as well as cockroach nerves, but the small size of the fibers makes it difficult to show positively that the reversal is in the sheath. Presumably the situation is the same as in cockroaches except for the small size and low amplitude (Figs. 14–15).

The protein component of the individual nerve sheaths of insects may be collagenous as in other animals (see *e.g.*, Schmitt, Hall & Jakus, 1942). Direct proof of this was not obtained but alcohol-extracted single-fiber preparations from cockroaches observed during treatment with dilute acetic acid showed a reduction and eventual loss of sheath birefringence. This would be expected for collagenous sheaths.

The lipid component of the individual nerve sheaths of insects seems almost certainly to include phosphatids as in other animals (Schmitt, Bear & Palmer, 1941). The solubilities of the sheath components are consistent with the idea that they include phosphatids. Also it is possible to extract considerable quantities of phosphatids and other myelin constituents from bee brains (unpublished data by Dumm, Patterson & Richards).

Metatropic nerve sheaths are found on axons throughout the insect. They are best studied from interganglionic connectives and large peripheral nerves (*e.g.*, cercal nerve) but they can be demonstrated throughout ganglia and in small distal peripheral nerves. Likely these sheaths extend over the nerve cell bodies

themselves but this was not studied. Chinn (1938) reported that a sheath continuous with and similar to the axon sheath extends over the nerve cells of lobsters, crayfish and leeches.

The metatropic nerve sheaths of cockroaches and mosquito larvæ exhibit numerous of the properties already described for other nerves. Birefringence is quickly lost following mechanical injury. The metatropic effect is lost on air-drying. Absolute ethyl alcohol removes the lipid quickly but weak alcohol removes it slowly with the production of birefringent particles that are stainable with Sudan dyes (Richards, 1943). Other lipid solvents except acetone also quickly block the metatropic effect (phosphatids are relatively insoluble in accetone). The metatropic reversal is most readily demonstrated by immersion in glycerine solutions but it can also be produced by other solutions of high refractive index (*e.g.*, sucrose) and is independent of shrinkage. The amplitude is somewhat reduced by fixation with formalin, etc., but after fixation with non-lipid solvents the lipids are more strongly bound and difficult to remove (see Mezzino, 1931). Likely there is also a relation between fiber diameter and amplitude of birefringence; certainly the larger nerves of cockroaches show more birefringence than the small nerves (see Schmitt & Bear, 1939, Fig. 1).

Cockroach nerve cords degenerating in saline show first a decrease in amplitude and then loss of the birefringence of the axis cylinder, then a gradual decrease and loss of the lipid component of birefringence. Nerve cords degenerating in glycerine-saline solutions, however, give rise to sphærites which gradually decrease in size and eventually disappear (Fig. 16). These birefringent sphærites originate from the sheath lipids, they can be produced by weak alcohol or degeneration in glycerine but have not been found to occur in cockroach nerve cords degenerating in saline (compare Baldi, 1929). The lipid component can also be abolished by the action of cobra venom which is known to contain phosphatase enzymes. They are also affected by certain insecticides; these data will be treated in subsequent papers.

Insect nerve sheaths differ quantitatively from other nerves in the low order of birefringence and especially in the very close balance of positive and negative components. The balance of

these components seems closer in insect nerve sheaths than in other recorded metatropic nerves. Only 10–15 per cent glycerine is needed to effect reversal of sign in the insects studied, whereas 30 per cent glycerine is required for Crustacea, 35–40 per cent for squid giant fibers, 50 per cent for non-myelinated spinal ganglion cells of the frog, and 70 per cent for leech nerves. In all of these the refractive index of the anisotropic micelles is reported to lie in the range 1.56 to 1.60; accordingly this variation in necessary refractive index of the immersion media likely indicates roughly the ratio of protein birefringence to lipid birefringence in the various nerves.

METATROPIC NERVE SHEATHS IN OTHER ARTHROPODS

A hasty survey was made covering a number of scattered arthropods to see if the type of nerve sheath studied in the cockroach and mosquito is to be found throughout the Annelid-Arthropod complex. All species examined exhibited metatropic nerves. Species examined by the author were an unidentified spider, a centipede (*Scutigera* sp.), a millipede (*Fontaria* sp.), a caterpillar (*Lymantria dispar*), a beetle (*Scarites subterranus*) the honey bee (*Apis mellifica*) and also a marine polychæte worm (*Nereis virens*). Other authors have already reported on the earthworm (*Lumbricus* sp.), the medicinal leech (*Hirudo medicinalis*), *Limulus* and various Crustacea (prawn, shrimp, crayfish, crab, lobster).

With all the major groups of the Annelid-Arthropod complex except the Onychophora represented in the above list, it certainly seems probable that Schmitt & Bear were correct in suggesting that metatropic nerve sheaths would be found throughout these phyla.

THE NEURAL LAMELLA

Around the outside of the nerve cord and of peripheral nerves is a homogeneous sheet secreted by an underlying layer of nonnervous cells. Scharrer (1939) studied this rather extensively in cockroaches and termed the cell layer the "perineurium" and the secreted sheet the "neural lamella." She pointed out that the neural lamella is optically homogeneous and stains with dyes like the connective tissue of vertebrates. It is several microns

thick in cockroaches but is too thin to measure in mosquito larvæ. It seems to be present in all insects but is commonly very thin and inconspicuous.

The neural lamella is strongly birefringent. It shows as a bright line along the edge of all nerve cords and is positively birefringent in relation to the long axis of the nerve cord (Fig. 12).[18] In cross sections it shows a strong negative polarization cross. Immersion experiments show that its birefringence is almost entirely due to form birefringence, but attempts to determine the refractive index by immersion methods encountered the same sort of difficulty recorded by Castle (1936) for chitin. Imbibition or oriented imbedding in some cases gives quite different measurements for media of the same refractive index. The refractive index seems most likely in the neighborhood of 1.47, and clearly is different from both chitin and the sheaths (collagen ?) around individual nerves. Although the neural lamella shows as a bright line due to its depth, the true magnitude of its birefringence is quite low. Using equation (4), $n_1 - n_2$ is found to be approximately 0.00022.

The neural lamella is unaffected by extraction with lipid solvents. It is completely and readily dissolved by strong alkali, and accordingly is not chitinous. It gives a strong protein reaction (xanthoproteic test) but seems not to be collagen since it does not swell, dissolve or even lose its birefringence in dilute acetic acid (3 days) and since immersion experiments give different results for the neural lamella and the presumably collagenous sheaths around individual nerves. Serial sections show that the neural lamella is composed of concentric thin layers. Attempts to obtain electron micrographs showed only that the neural lamella fractures in an irregular manner suggesting a non-fibrous structure. Stretching experiments show that the neural lamella is elastic and possesses strong, photoelastic properties.

18 The neural lamella does not interfere seriously with a study of the birefringence of the included nerves. It shows only as a bright line along the edge, and can be ignored. Proof that it does not interfere with readings made on the included nerve bundle comes from experiments in which the same reading was obtained for the nerve bundle before and after manual removal of the neural lamella.

The above data suggest that the neural lamella of cockroaches is a series of elastic, homogeneous, concentric sheets composed of anisodiametric protein micelles exhibiting form birefringence and arranged with their optic axes perpendicular to the surface of the sheet. The negatively uniaxial protein micelles are arranged with their optic axes at right angles to the nerve axis, and accordingly the neural lamella appears positively birefringent in relation to the axis of the nerve cord.

No attempt has yet been made to study accurately the permeability of the neural lamella but obviously it must be permeable. Exchanges with the blood must take place through it, fixing fluids used in histology penetrate rapidly, and even the rather large aggregates of solubilized detergents—Black Sudan B (a polyazo dye) penetrate the neural lamella more rapidly than they will dialyze through a collodion membrane.

The birefringence of the neural lamella of a wasp and a beetle has already been described and figured by W. J. Schmidt (1937, p. 273, Fig 70), but seemingly Schmidt erroneously thought that this sheet compared with the sheaths of single vertebrate nerves.

DISCUSSION

The data presented in this paper supplement those given previously (Richards, 1943), and show that the structure of insect nerves and nerve sheaths is closely similar to the structure reported for other animals (see Schmitt & Bear's review, 1939). This structure is diagrammed in Figure 4. Around the outside of insect nerves and nerve cords is a secreted sheet, the neural lamella, which while serving the same protective purpose is different from the protective coatings around vertebrate nerves and nerve cords.

Few observations on the birefringence of insect nerves are to be found in the literature. Bruno (1931) reported that insect nerves (various species) are isotropic. This bare statement cannot be evaluated in the absence of any information on the method of preparation and the type of compensator employed. Perhaps the negative report is simply an expression of failure to recognize the extremely low amplitude of relaxed insect nerves. W. J. Schmidt (1937) has already refuted Bruno's report. He pub-

lished a figure showing the birefringence of a fresh peripheral nerve from the head of a wasp (Fig. 70, p. 273) and described similar results obtained with the ventral nerve cord of a beetle. From his brief comments, however, it is not certain how clearly he distinguished the various components of the birefringence. Certainly the sheath to which he refers is the neural lamella; he seems not to have seen the sheaths of the individual nerves or to have determined their lipo-protein character. Recently Pfeiffer (1943) has studied the growth of single nerves from *Corethra* larvæ (Diptera) in tissue culture. He records a positive uniaxial birefringence for normal *Corethra* nerves, with an amplitude of birefringence comparable to that described herein for mosquito larvæ. Pfeiffer was interested in studying nerve growth; he does not mention nerve sheaths and seems not to have distinguished between sheath and axis cylinder effects or to have recognized the presence of metatropic sheaths.[19]

Numerous references can be found in entomological literature stating that insect nerves are non-myelinated. These statements are readily understandable in view of the extreme thinness of the sheaths (commonly submicroscopic) and the correspondingly low lipid content.

SUMMARY

1. Insect nerves and nerve cords in saline solutions show a positive uniaxial birefringence in relation to the length of the fiber. This is reversed to negative by immersion in media of higher refractive index, *i.e.*, the nerves are metatropic. Qualitatively they seem to agree well with the structure of other so-called non-myelinated nerves as recorded by Schmitt, Bear and others. A diagram presenting the orientation of the optically active micelles is given in Figure 4.

2. The axis cylinder of insect nerves shows largely form birefringence which is positive in relation to both the nerve axis and the optic axes of the micelles. Most of this birefringence is due

[19] The extremely small size of these nerves may have caused Pfeiffer to overlook the sheath. In nerves of comparable size from mosquito larvæ the sheaths are of submicroscopic thickness. Another possibility is that insect nerves growing in tissue culture may possibly differ from nerves growing in an animal.

to micellar form but a small residue of intrinsic birefringence seems to be present. The amplitude of birefringence of the axis cylinder increases greatly on being stretched.

3. Each insect nerve is surrounded by a discrete sheath of lipoprotein. In thickness these sheaths are at most only a few per cent of the fiber diameter, and accordingly in the case of small nerves are too thin to be observed directly (submicroscopic). This sheath is responsible for the metatropic reversal effect. Both the lipid and protein components are oriented with the optic axes of their micelles arranged radially. They are of opposite sign. Normally the nerve sheaths appear positively birefringent in relation to the nerve axis because the positive component due to the proteins slightly overbalances the negative component due to the lipids. Removal of the intrinsically birefringent lipid increases the positive birefringence and prevents metatropic reversal. Masking the form birefringence of the protein permits the intrinsic birefringence of the lipids to be seen (metatropic reversal).

The protein component of the sheath may be collagen. Its micelles are negatively birefringent in relation to their optic axes but being arranged radially make the nerve appear positively birefringent in relation to its length. Its birefringence is mostly due to micellar shape but a small residue of intrinsic birefringence seems to be present.

The lipid component of the sheath is probably a mixture of phosphatids with perhaps other "myelin" components. The lipid micelles are positively birefringent in relation to their optic axes but being arranged radially make the nerve appear negatively birefringent in relation to its length. The lipid birefringence is intrinsic since it is unaffected by the refractve index of immersion media.

4. Insect nerves seem to differ from the non-myelinated nerves of other animals chiefly in the low order of amplitude of birefringence and the extreme thinness of the nerve sheaths. These seeming differences may possibly be illusory since ordinarily only large nerves are studied whereas insect nerves are commonly very small.

5. Metatropic nerve sheaths have been reported to date in an earthworm, sandworm and leech (Annelida), a spider and *Limu-*

lus (Arachnida), various shrimps, crabs, etc. (Crustacea), a millipede (Diplopoda), a centipede (Chilopoda) and five orders of pterybote insects (cockroach, mosquito, moth, bee, beetle). It certainly seems probable that at least for the Annelid-Arthropod complex Schmitt & Bear were correct in suggesting that metatropic nerve sheaths will be found throughout the invertebrates.

6. Around the nerve cord and peripheral nerves is a secreted permeable elastic layer, the neural lamella, which is structurally and chemically different from the protective coatings around vertebrate nerves. The neural lamella is or at least contains a protein which shows form birefringence and photoelastic properties. This protein seems to be different from collagen and different from the protein of the sheaths around individual nerves. Immersion experiments are complicated by the oriented imbedding of imbibed media. The neural lamella is composed of thin concentric layers with the micelles arranged perpendicular to the surface (radial in relation to the nerve). These micelles, like sheath proteins, are negatively uniaxial in relation to their optic axes; being arranged radially they make the sheet appear as a positively birefringent line (in relation to the nerve axis) along the edge of the nerve.

LITERATURE CITED

BALDI, F. 1929. Richerche sulla degenerazione Walleriana. Primo indagini a luce polarizzata. Riv. Neurol., 2: 56–63.

BEAR, R. S. AND F. O. SCHMITT. 1936. The optics of nerve myelin. Jour. Optical Soc. Amer., 26: 206–212.

———. 1936. The measurement of small retardations with the polarizing microscope. Jour. Optical Soc. Amer., 26: 363–364.

BEAR, R. S., F. O. SCHMITT AND J. Z. YOUNG. 1937. The sheath components of the giant nerve fibers of the squid. Proc. Roy. Soc. London, B, 123: 496–504.

———. 1937. The ultrastructure of nerve axoplasm. *Ibid.*, 123: 505–519.

———. 1937. Investigation of the protein constituents of nerve axoplasm. *Ibid.*, 123: 520–529.

BRUNO, G. 1931. Sulla struttura dei nervi di alcuni insetti. Monit. Zool. Ital., 42: 8–15.

CASTLE, E. S. 1936. The double refraction of chitin. Jour. Gen. Phys., 19: 797–805.

CHESHIRE, F. J. 1932. The polarization of light. Jour. Television Soc., ser. 2, 1: 201–207.

CHINN, P. 1938. Poralization optical studies of the structure of nerve cells. Jour. Cell. Comp. Phys., 12: 1–21.

——— AND F. O. SCHMITT. 1937. On the birefringence of nerve sheaths as studied in cross section. Jour. Cell. Comp. Phys., 9: 289–296.

FISCHER, E. 1944. The birefringence of striated and smooth mammalian muscles. Jour. Cell. Comp. Phys., 23: 113–130.

MEZZINO, L. 1931. Rifiessioni ed osservazioni istologiche sulle fibre nervose midollate. Riv. Biol., 13: 31–56.

MIHALIK, P. 1934. Mechanisch-experimentelle Untersuchungen über die Doppelbrechung der Markhaltigen Nervenfaser. Zts. Zellforsch. mikr. Anat., 21: 653–656.

MYERS, L. M. 1938. Television Optics. 2nd Ed. 362 pp. Pitman & Sons, London.

PFEIFFER, H. H. 1943. Polarizationsmikroskopische Messungen an gerichtet gespannten Mutterstücken von Ganglienkulturen in vitro. Naturwiss., 31: 47–48.

RICHARDS, A. G. JR. 1943. Lipid nerve sheaths in insects and their probable relation to insecticide action. Jour. N. Y. Ent. Soc., 51: 55–69.

———, H. B. STEINBACH AND T. F. ANDERSON. 1943. Electron microscope studies of squid giant nerve axoplasm. Jour. Cell. Comp. Phys., 21: 129–143.

SCHARRER, B. 1939. The differentiation between neuroglia and connective tissue sheath in the cockroach (Periplaneta americana). Jour. Comp. Neurol., 70: 77–88.

SCHMIDT, W. J. 1937. Die Doppelbrechung von Karyoplasma, Zytoplasma und Metaplasma. Protoplasma Monographien, 11: 1–388.

SCHMITT, F. O. AND R. S. BEAR. 1937. The optical properties of vertebrate nerve axons as related to fiber size. Jour. Cell. Comp. Phys., 9: 261–273.

———. 1939. The ultrastructure of the nerve axon sheath. Biol. Rev., 14: 27–80.

——— AND K. J. PALMER. 1941. X-ray diffraction studies on the nerve myelin sheath. Jour. Cell. Comp. Phys., 18: 31–42.

———, C. E. HALL AND M. A. JAKUS. 1942. Electron microscope investigations of the structure of collagen. Jour. Cell. Comp. Phys., 20: 11–33.

WERNDLE, L. AND G. W. TAYLOR. 1943. Sheath birefringence as related to fiber size and conduction velocity of catfish Mauthner, Müller and peripheral fibers. Jour. Cell. Comp. Phys., 21: 281–293.

PLATE X

In all figures the cross-hairs indicate the orientation of the Nicol prisms of the microscope. Extra contrast and compensation obtained with a Köhler $\lambda/20$ rotating mica plate compensator. Photographs, of course, do not distinguish between positive and negative birefringence; this is determined by compensators and stated in text and legends.

FIG. 5. Teased single large nerve fiber from cockroach nerve cord fixed in 95% ethyl alcohol in *relaxed* condition. Lipids extracted by alcohol. In distilled water; birefringence positive in relation to nerve axis. The parallel light lines represent the protein component (collagen ?) of the nerve sheath. Diameter of this fiber 16 μ. Magnification 300 ×.

FIG. 6. A group of medium-sized nerves from the same preparation as Figure 5. Diameters of these fibers 5–6 μ. Magnification 300 ×.

FIG. 7. A single small fiber, 3 μ in diameter, from same preparation. Note how faint the sheath is. Magnification 300 ×.

FIG. 8. A single teased cockroach nerve fiber which was fixed in 95% alcohol while *stretched* to approximately 1½ × its relaxed length. Note that the sheath and axis cylinder are of the same general intensity and so cannot be distinguished. Specimen in distilled water; birefringence positive in relation to nerve axis. Diameter of this fiber after stretching 10 μ. Compensator set for maximum brightness of nerve. Magnification 300 ×.

FIG. 9. Same but with compensator plate rotated for extinction of nerve retardation. Such brightening and extinguishing effects prove we are dealing with birefringent properties.

FIG. 10. Another nerve from the same preparation. Diameter 12 μ. Magnification 300 ×.

FIG. 11. Large group of nerve fibers from partly teased cockroach nerve cord in saline containing 15% glycerine (2 hrs.). The form birefringence of the protein is here masked sufficiently to give reversal of sign (metatropic effect); the sign of birefringence here is then negative in relation to the nerve axis. The many parallel light lines are due to the lipid components of a number of nerve sheaths. Nerves of various diameters (3–8 μ on plate but somewhat shrunken by the glycerine medium). Magnification 500 ×.

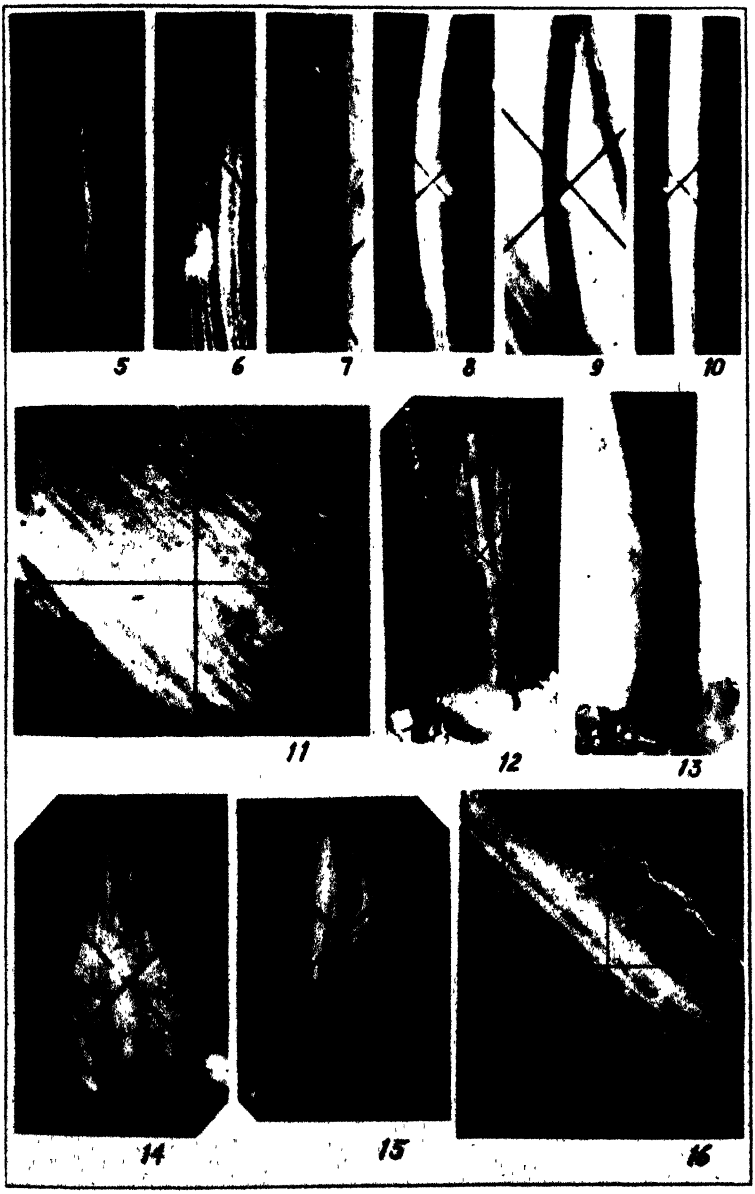
FIG. 12. A thoracic interganglionic connective of a cockroach in saline with 15% glycerine (15 min.). The bright lines along the sides are produced by the neural lamella. The bright interior is produced by the superimposed effects of the lipid sheaths of many nerves. The neural lamella is positive in relation to the nerve cord axis; the included bundle of nerves is negative. Compensator set for maximum brightness. Magnification 45 ×.

FIG. 13. Same but with compensator plate rotated for extinction of nerve retardation. In this photomicrograph the positive birefringence of the neural lamella is lost against the white background.

FIG. 14. Abdominal ganglion and interganglionic connectives of a mosquito larva. Fresh preparation in saline; birefringence positive in relation to nerve axes. Compensator set for maximum brightness. Magnification 200 ×.

FIG. 15. Same fresh preparation after 5 min. in saline containing 15% glycerine. The sign has reversed and the nerve cord shrunken slightly. Magnification 200 ×.

FIG. 16. Portions of two interganglionic connectives of a cockroach after 18½ hours degeneration in saline containing 15% glycerine. Shows the breakdown of the sheath lipids into birefringent sphaerites. The two bright lines running diagonally through the center are produced by the neural lamellæ of the two connectives. The wavy bright line in the upper right quadrant is produced by an air-filled trachea. Magnification 200 ×.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NOTES ON THE BEHAVIOR OF BURYING BEETLES (NICROPHORUS SPP.)

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For several summers, ending with the season of 1928, the senior author had observed species of *Nicrophorus* (Coleoptera, Staphylinidæ, Silphinæ) burying small carcasses at Irondale (Haliburton County), Ontario, Canada, in July. Some of his observations were published (Milne, 1928). Much more extensive and detailed studies of burying beetles were made by Pukowski (1933) in Europe and Leech (1935) in British Columbia. These authors followed the life history from the time of burial, while the adults cared for the young, through the three instars of larval life, the prepupal and pupal periods, and made observations on emergence and feeding of the adults. Difficulty was reported in observing the burying behavior because of its nocturnal nature and because *Nicrophorus* was not abundant enough to justify the risks of disturbing beetles at work. Since the burying activities had been watched repeatedly in daylight at Irondale, the present authors made a return trip there in the summer of 1944, to prepare a Kodachrome motion picture of the burying beetles in their work above ground. Although the time available during the brief vacation from war research greatly restricted the experimental studies, it was possible to make further observations which extend and clarify the behavior of these insects.

1. SPECIES INVOLVED AT IRONDALE

Six species of *Nicrophorus* have been collected at carrion in this region by the authors, namely *N. sayi* Lap., *N. orbicollis* Say, *N. marginatus* Fab., *N. pustulatus* Hersch., *N. vespilloides* Hbst., and *N. tomentosus* Web. All these are easily distinguished in the field. Only *tomentosus* has the pronotum covered with yellow, appressed hair (which often becomes abraded on the two convexities of the disc). Only *sayi* and *marginatus* have distinctly curved hind tibiæ. Only *vespilloides* and *tomentosus*

have the antennal clubs entirely black, the other species having at least part of the club orange red; these two species are also considerably smaller in average size. *Sayi* and *orbicollis* are very similar in markings, with the elytra mostly black, but with orange red in a sub-basal, irregular crossbar and a subapical spot. *Marginatus, vespilloides* and *tomentosus* are similar in markings, the elytra being mostly orange red, the bands of color continuing across both elytra, sometimes confluent also along the outer margins. *Pustulatus* is unique among these six species in having the pronotum transversely oval, the others having a circular disc; it also has the sub-basal elytral spot small or absent, the subapical bar often divided in two (sometimes lacking), the insect thus having an even blacker facies than *sayi* or *orbicollis.* Of these, only *tomentosus* and *orbicollis** were numerous in late July of 1944, and on them most of the following notes are based.

2. METHODS OF STUDY

Irondale is a hilly region from which the original timber was removed perhaps fifty years ago. Those areas which could be freed of glacial erratics and which were reasonably level, have been farmed (chiefly for grain). Other areas have been cleared for pasture and kept available for sheep and cattle. Less level land has been allowed to grow up again. The vegetation is typical Canadian zone, with hemlock, spruce, pine, paper birch, poplar, spiræa, sweet fern, sweet gale, mountain laurel, club mosses, bracken, and an abundant lichen flora on exposed rocks and tree trunks. Among the larger fauna are loons, whip-poor-wills, porcupines, groundhogs, skunks, red squirrels and chipmunks. Most of the glacial lakes contribute to the Burnt River system, deriving the name from the dark color of the water, due to leaching of iron ore from rock substratum and to solution of decaying coniferous and other xerophytic debris. Sphagnum is common and pitcher plants and sundew reach large size.

To attract *Nicrophorus,* small dead animals were placed at selected positions in a variety of ecological habitats. Each carcass was secured to a nearby stake by a two-foot length of fine steel wire, to make recovery easy (*cf.* Milne, 1928). The animals used

* Referred to as *N. pollinctor* in Milne, 1928.

were chiefly deer mice (*Peromyscus*), with some house mice (*Mus*), shrews (*Blarina*), birds (robins, thrushes, sparrows, wrens, domestic turkeys, etc., as found dead) and snakes. In previous years larger carrion was tried, including groundhog (*Marmota*), skunk, dog, etc., but *Nicrophorus* was found to show little interest in carcasses too large for them to bury. For species observed at Irondale, a body the size of a robin is perhaps the limit.

In open fields, such as pastures or where hay had been cut, *N. tomentosus* and *marginatus* arrived to bury mice and snakes. Competition with ants was frequent and the carcasses deteriorated considerably before the beetles could get them buried. In leaf litter from birch and poplar, second growth woodland, *N. tomentosus* and *orbicollis* were quick to bury mice and birds. In coniferous duff the same species were somewhat slower in finding carrion. No activity was observed on mice placed in low, wet positions such as sedgy swales. Mice placed on particularly hard ground or on bare rock, were transported by the beetles to places where the soil was less packed and burial hence easier. Desiccation of carcasses by the sun did not have any noticeable effect on the interest in them shown by the beetles.

3. BEHAVIOR OF THE BEETLES

Nicrophorus exhibits a number of interesting behavior patterns. The beetles fly to the general vicinity of the carrion, apparently by smell (*cf.* Abbott, 1927a & 1927b; Milne, 1928). *Tomentosus* is particularly accurate in locating the body before alighting, buzzing through the bushes like a bumblebee. The resemblance to *Bombus* is enhanced by the golden body hair, the yellow inner surfaces of the elytra (which are held back to back over the midline) and the creamy cast to the flying wings. All *Nicrophorus* run about briskly, forcing their way through or under tangled vegetation. If disturbed, all but *tomentosus* are likely to either feign death, or run away a few feet to hide in grass roots. *Tomentosus* takes to its wings and may alight in a nearby bush, often standing on a slanting stem rather than the broader surface of a leaf. Pukowski (1933) describes a similar habit as part of the behavior of a lone *Nicrophorus* attracting a

mate, the beetle climbing a stone or plant, elevating the abdomen obliquely and extending it so much that the coriæ are visible. No indication of such was observed by the present authors, a lone *Nicrophorus* regularly getting to work on the burial task and continuing so engaged until a mate arrived.

After a beetle has arrived at a dead animal, it characteristically examines the body with palpi and antennæ and tests the size of the carcass by trying to move it. The "carrying" action is one of the most typical behavior patterns shown by *Nicrophorus*. Another activity closely related is that of "exploring" the surrounding soil for a suitable spot in which the body may be interred. A third procedure is to test the looseness of the soil by "plowing" it. All of these behaviors are energetic, and are shown by even a single *Nicrophorus*.

The carrying action of *Nicrophorus* demonstrates the strength of the beetles and the vigor with which they proceed wtih their task. To move a carcass, say forward in terms of a mouse's body, the beetle crawls under the head of the mouse, turns over on its back, and lifts the mouse bodily over itself. The mouse inches forward little by little, while the beetle slides slowly on its smooth back under the mouse until it reaches the posterior end. There it either emerges and runs around to the anterior end of the mouse again, or turns over on its feet to crawl under the mouse, the smooth dorsum of the beetle not disturbing the body. Such effort is very strenuous, and a rest period or an exploring interlude usually follows a few minutes of moving the carrion. A single beetle rests more than when a mate has arrived. A slight tug at the carcass usually stimulates it to renewed activity. When two beetles are operating one or the other is usually carrying the body while the mate explores or plows. No sexual difference in degree of activity could be noticed (*cf.* Wood, 1873; Furneaux, 1893; Pukowski, 1933). Both members of a pair were highly industrious under most circumstances. On level ground devoid of major obstacles, a pair of beetles may transport a full-grown mouse or shrew as rapidly as three or four feet per hour, and keep up this pace for as much as two and a half hours, the limit in every case observed being the distance necessary to reach sufficiently soft ground for burial use.

The exploring behavior was very distressing to the observers. After a shorter or longer period of work on a carcass, one or both members of a pair will suddenly leave the body and run away from it at the usual brisk pace. The beetles may go only a few feet (seldom less), or as much as a few yards, and in some cases (*tomentosus*) took to flight, only to return in a matter of minutes. A specimen of *N. tomentosus* with a broken elytral tip was observed to fly off and back again four times within an hour. Each time it flew out of sight. During the hour perhaps fifteen minutes work was done in carrying the mouse and in plowing in nearby soil, the remainder being either exploring the whole surrounding area (perhaps fifteen feet in diameter), or resting with head under a clump of grass, or absent altogether while away on a flight. This procedure persisted even after the specimen was joined by a mate, continuing until the carrion had been transported (mostly by the mate, in this instance), almost to the area selected for burial use.

The plowing procedure loosens the earth. The beetle uses its head as a plowshare or bulldozer, pressing into the earth perhaps the depth of its stout body below the surface, then forcing its way forward in an arc while maintaining its depth. The earth is forced upward and crumbles. Any roots encountered are either forced aside, or chewed through, but if numerous a new burial site is sought out. Before a final area is considered satisfactory, as many as twenty possible sites may be plowed and found unsuitable. The final area may be many feet away from the carrion, and the beetle(s) will alternately work on the carcass and run to the burial site to do another stretch of plowing. The route taken between carrion and burial site is usually fairly direct, and the body is carried along this line. How both members of a pair can agree on a site was not determined, nor was it at all clear how the beetles were able to keep the carcass moving so uniformly (few exceptions) in one direction. The contrast was very marked between the cooperation of *Nicrophorus* and the great wastage of effort among ants trying to carry a large food particle.

In a few instances, the beetle bait was placed on soft ground and the *Nicrophorus* buried it where it lay. In all instances,

however, the burial procedure was a localization of the plowing action. The beetles plowed *under* the carrion, entering at one side (or end) and emerging at the other, only to turn about and complete the shuttling action. On each emergence at the side or end of the carcass, a sizeable amount of earth was forced up, to accumulate in a loose pile all around the body. Gradually the earth from below the carrion was displaced to the side and the carcass settled into the ground. A continuation of the same activity gradually drops the body below the surface of the ground, and the procedure is continued until as much as two inches of earth are over the carcass. The body is usually let into the ground at a steep angle. Not only the earth under the carrion, but also that within a few inches of it is plowed. Closer to the body the ground is plowed to a greater depth. In its final site, a chamber is cleared of earth below and to one side from the body. In the chamber *Nicrophorus* remains after burial. The chamber may be as much as two and a half inches long, an inch wide and deep, and the walls are left packed in the original condition of the earth, so that cave-ins are unlikely. Burial is usually completed in five to eight hours, although the beetles will continue for days if obstructions slow their work. *Nicrophorus* usually remain with the carrion at least for many days (*cf.* Hatch, 1927b; Milne, 1928; Pukowski, 1933; Leech, 1935).

There seems to be a relationship between the size of the carrion, the size of the *Nicrophorus* species and the number of pairs which can work in burying it. A full sized robin (in juvenile plumage) was handled by a pair each of *N. orbicollis* and *tomentosus*. A thirty-inch garter snake was buried by two pairs of *N. tomentosus* and one of *marginatus*. In one instance a full-grown deer mouse was interred by two pairs of *N. tomentosus*. In all other instances only a single pair of a single species did the work. Additional specimens of *orbicollis* arriving at a piece of carrion where a pair were at work, usually crawled under the body, only to emerge (promptly!) pursued by one of the original pair. Several rough and tumble fights were witnessed in which the newcomer resisted briefly the attack of the original "owner." *Orbicollis* coming to carrion where *tomentosus* was at work usually drove the smaller species away. *Tomentosus* coming to

a carcass being carried or buried by *orbicollis* usually left without any indication of expulsion. *Tomentosus* coming where *tomentosus* were already at work sometimes helped awhile before leaving, in only one instance (see above) remaining until the body was completely interred. Thus *tomentosus* would seem to make up in small size, greater numbers (see below) and more sociable reactions for its inability to compete physically with the larger species. *Orbicollis* becomes quite excited over expelling a competitor and stridulates very audibly by rubbing the upper surface of the abdomen against the under surface of the elytra (*cf.* Morley, 1902). This same stridulation is observed when a pair mate (3 to 4 seconds; *cf.* Pukowski, 1933), or when an obstruction continues to bar the way in moving a carcass. These were the only occasions and the only species in which such noises were noted. Pukowski (1933) indicates that pairs working on a carcass keep in contact with each other by alternately emitting "zirping" sounds.

Obstructions may be of a variety of types. Naturally encountered are situations where roots, stems, leaf petioles, etc., are sufficiently anchored at both ends as to restrict an opening through which the beetle is attempting to move the carrion. The beetle discovering such an obstacle usually tries first to force it out of the way, getting head and pronotum under the restraining strand, feet in the vestiture of the carrion, and crawling ahead. Many obstructions can be stretched sufficiently by this method to open a suitable passage for further progress of the carcass. When force proves inadequate, the beetle may settle down on the restraining piece and laboriously chew it through. Often periods of chewing are alternated with episodes of drawing and pushing at the carcass or strand, the chewing frequently having weakened the obstruction sufficiently to let it give. When the obstacle proves too resistant to such treatment, soil is plowed from under the carcass and the needed space obtained in this way.

Obstructions provided experimentally were usually very irritating to the beetles but in no case did they leave permanently. String tried to the leg or tail of a mouse was the commonest form of restraint, and one which could be overcome by gnawing the string until it broke under strain. Fine steel wire was an in-

superable difficulty. A carefully placed piece of rock, supported partly on the ground and partly on the body of a mouse, proved less of a problem. Although the rock weighed several pounds, the pair of beetles working together were able to lift the rock where it rested on the mouse sufficiently to push the carrion free of its pressure and restraint.

One experimental situation gave a good demonstration of the beetles' behavior. A mouse laid out on fairly soft ground had a string tied to one hind leg, the opposite end of the string being fastened to a stake close to the mouse but in such a way that the string was almost vertical and held the leg clear of the ground. A pair of *N. orbicollis* proceeded to bury the mouse. They did a fine job, the head of the mouse finally hanging almost vertically downward into the hole the beetles had excavated. The hind leg continued to be supported in its original position. The beetles cleared away the earth until there was none below the head and shoulders of the mouse for a distance equal to the thickness of a beetle, and a space was also clear all around the mouse so that it hung by its one leg over a sizeable, cup-shaped hole. With much stridulation and rotation of the mouse around and around over the hole, the beetles failed to go vertically upward to the supporting string. Every move in this direction ended in a trip out the length of the mouse's tail, to see that it was free. It was, but the traffic became so heavy and the mouse so "ripe" that the skin rolled off the tail distally like a glove finger. Finally the beetles gnawed the tail off the mouse, severing it at the root. Almost at once they found the supporting string, and after a few abortive attempts to free the foot, one of the *Nicrophorus* settled down to the task of gnawing it through. When the string gave way, the mouse collapsed in a heap into the bottom of the hole prepared for it, and burial was completed uneventfully within half an hour.

Pukowski (1933) indicates that the beetles prepare a conical hole below the carrion, always smaller than the body, and fold the carcass as they draw it into the pit. The episode just described would seem to indicate that *Nicrophorus* continue to enlarge the hole for the carcass until it has been sunk to their satisfaction, and that a conical hole and consequent folding may

be merely economy of effort. When carrion has considerable length, as for example a snake, no folding was observed by the present authors. The snake was let into the ground to a depth of nearly two inches all along its length (except for the tail), so that it was buried horizontally, in approximately the attitude occupied previously on top of the earth. It is true that in the case of snakes, burial advanced rapidly in the region from head to anus, the tail being left out in the air for nearly twenty-four hours after the remainder of the carcass was well under the surface. The tail, with its smaller supply of food materials, was obviously of much less interest to the beetles, forming chiefly an obstruction to satisfactory burial. In several instances the last few inches of a snake's tail was chewed off, and the postanal remainder pulled into the ground after putrefaction had rendered it more plastic.

Heavy rain obstructed burying beetles much less than had been expected. On several occasions *Nicrophorus* had begun to bury bait placed on level, hard ground, when torrential downpours drove the observers to nearby shelter. From the cabin the bait could be seen almost or quite covered by water, sometimes to a depth of an inch. No sign of the beetles was noted, yet within fifteen minutes after the rain slackened enough for the ground to drain off, the insects were busy in the wet earth, excavating, plowing and tugging the carcass into their cavity.

The observers' concern over the seeming desertion of the bait whenever *Nicrophorus* went into an exploring episode, suggested another experiment. As indicated above, the beetles frequently explore a very sizeable area befor returning to the carcass. There is no indication, however, that there is ever any difficulty in finding the carcass again, since the beetles often return to it in an almost straight line from a distance of a yard or two. On several occasions, duplicate baits were tried, being mice of approximately equal size and state of preservation, placed a foot apart on even terrain. A *Nicrophorus* would come to one, test it for size, then explore the surrounding ground for a suitable burial site. During the exploration the second mouse was usually discovered. Almost without exception, the beetle examined the duplicate bait without attempting to carry it, then hurried back to the mouse

previously discovered. In no case observed did the beetle(s) desert the first bait in favor of the second. The same type of experiment was tried on pairs which were busy burying a relatively fresh mouse. A similar (or more odoriferous) mouse was placed where they would surely find it during exploration trips. In no case did the beetles desert the first-found carcass to more than examine the second. It was quite obvious that the extra carrion so nearby was a source of great distraction, but the recognition of one body as distinct from another was most marked.

In only a few instances did *Nicrophorus* show any indication of feeding on the carrion (*cf.* Furneaux, 1893; Lutz, 1921; Steele, 1927; Milne, 1928). Usually the beetles seemed to be in a hurry to get the carcass interred. During daylight the need for rapid burial was great, since blowflies came in considerable numbers, laying living larvæ if unmolested for a few minutes. The brisk activities of the beetles and the frequent jerky movements of the carcass have a deterrent effect on flies of some types (including blowflies) but where obstacles prevented beetles from quickly getting the carrion under ground during daylight hours, it was obvious that little of the carcass would be available for other than dipterous larvæ. In many instances the beetles seemed to realize this, and failed to complete burial. In some cases *Nicrophorus* left fly-ridden carcasses sunk below the level of the ground, covered by perhaps a quarter of an inch of loose earth. A few days later such carrion was a squirming mass of fat fly larvæ. Rapidly buried bodies, on the other hand, are remarkably free of dipterous contamination. This may well be due to the preference shown by beetles for operations in twilight, at night or on cloudy (even rainy) days (*cf.* Abbott, 1927b) or an active eating of young maggots by the beetles (noted on a few occasions; *cf.* Steele, 1927; Leech, 1935).

In one instance of *Nicrophorus* feeding, one member of a pair took time off to investigate a small hole in the abdomen of a "ripe" mouse, while the mate was busy excavating under the carcass. For perhaps five minutes the feeding beetle worked into the hole, until head and pronotum were inside the abdominal wall. The viscera were explored rather superficially since the position of the head could be discerned at all times by the moving

elevation it produced in the mouse's skin. It was the observers' opinion that the beetle was drinking rather than eating. Prior to this feeding action, small flies had found the hole in the mouse's abdominal wall a very interesting region, and considerable moisture seemed to be present. After the beetle left the hole, there was no liquid visible and no flies were attracted to the area. During feeding, several blowflies ran against the posterior end of the beetle, and were kicked away by violent movement of the posterior legs. This kicking of molesting flies and ants seems a common reaction in *Nicrophorus*.

Nicrophorus apparently discovers carrion entirely by smell, while ants frequently locate freshly killed mice, seemingly as part of routine foraging operations. Often ants had removed the lips and nosetip of the rodent (the first part to be attacked in all instances observed) before *Nicrophorus* arrived, but on warm days (or nights) the beetles began to arrive within an hour or less. Typical of the speed with which *Nicrophorus* gather at a mouse is the following record made between six and ten o'clock one warm evening:

5:30 P.M.	Freshly killed mouse laid out in birch leaf litter.
6:05	♀ *N. tomentosus.*
6:07	♂ *N. tomentosus.*
6:19	♂ *N. tomentosus.*
6:38	♂ *N. orbicollis.*
6:40	♂ *Silpha americana.*
7:33	♀ *N. tomentosus.*
8:02	♀ *N. orbicollis.*
8:13	♂ *N. orbicollis.*
8:36	♂ *S. noveboracensis.*
8:41	♀ *S. americana.*
8:47	♀ *N. orbicollis.*
9:00	♂ & ♀ *S. noveboracensis.*
9:40	carabid beetle.
9:50	♂ *N. tomentosus.*
10:00	Took in mouse for the night.

Thus in four hours, nine *Nicrophorus* arrived, of which approximately half were males. The sex ratio is remarkably close to 1:1. Of twenty-two specimens of *N. orbicollis* collected in the sequence

in which they arrived (no selection), ten were females. Of forty-one *N. tomentosus* collected in the same way (and during the same time limits), twenty were males. Other observers confirm the sex ratio (*cf.* Wood, 1873; Leech, 1935). The ratio of twenty-two *orbicollis* to forty-one *tomentosus* is a very good value to indicate the relative abundance of the two species in deciduous woodland. In the sample catch cited above in chronological order, the proportion of *N. tomentosus* is unusually low. Some may have been driven off by *N. orbicollis* between arrival of *orbicollis* and the frequent visits of the observers. Mosquitos made more constant supervision too uncomfortable.

Another indication of the frequency with which *Nicrophorus* come to carrion was afforded by an unintentional experiment. Usually the observers placed all bait which was to be saved for the morrow in a glass jar to be kept overnight on ice. On one occasion a relatively fresh mouse was tossed casually into a butterfly net, the net folded on itself a few times, and left standing outside the cabin over night. In the morning two *N. tomentosus* were collected on the outside of the net just over the mouse inside. Holes had been chewed through the net thicknesses to allow entry of five other *Nicrophorus,* two *orbicollis* which had reached the mouse, one *orbicollis* nearby in a fold of the net, and two *tomentosus* in still other folds. Concern over the damage done to the net precluded observations on how the beetles might have gone about burying a carcass under such conditions.

The authors have been unable to identify the sex of *Nicrophorus* in the field without examining the genitalia—a procedure which is accomplished more satisfactorily on an anæsthetized specimen. Records for *N. orbicollis* were kept, however, to determine if there were any clue to sex in the size of the specimens. Ten male and eleven female *orbicollis,* measured freshly killed and extended, form the basis of study. Since the telescoping of the abdomen provided an independent variable, measurements were made from the most anterior part of the head capsule to the elytral apex. For the ten males there was a variation in this measurement from 14 to 22 mm., mean 19.6 mm., with a standard error of 2.7 mm. or approximately 14%. For the eleven females the variation was from 16 to 22 mm., mean 18.5 mm., with a

standard error of 2.2 mm., or nearly 12%. Since the difference between the means is only 1.1 mm. (about 6%), the authors were unable to use size for sex recognition. A small male and a large female, or vice versa, were encountered more frequently than two large or two small specimens.

Due to the preference shown by *Nicrophorus* for work in the shade or at twilight or night, difficulties were experienced in obtaining photographic records. So as to have beetles available to photograph when the light was good, attempts were made to imprison photogenic specimens in glass jars with a little earth. If the earth were moist, isolated specimens burrowed into it and were active the following day, showing little agitation over their confinement and taking on the burial of any mouse provided them as soon as liberated quietly beside it. However, the beetles became very hungry when kept over night, and unless maintained in solitude, resorted to cannibalism. Specimens killed by their fellows were ripped apart most ruthlessly, head from pronotum from remainder of thorax from abdomen, and each part cleaned of viscera. The victors frequently lacked tibiæ, antennæ, sometimes whole legs and elytra, demonstrating the ferocity of the battles. *Onthophagus,* histerids and larvæ of *Silpha* seemed able to escape such attacks, but adult *Silpha* and *Nicrophorus,* as well as other staphylinids and scarabæids (*e.g.*, *Geotrupes*) were destroyed by hungry *N. orbicollis* and *tomentosus.* When specimens were confined without food for more than a day, they became sluggish and often died. Pukowski (1933) mentions *N. germanicus* attacking adult *Geotrupes silvaticus,* capturing them at horse dung, seizing them in the legs and mandibles and devouring the viscera. *Nicrophorus* rolls over on its back or one side while eating such prey.

4. RELATED OBSERVATIONS

Among other species frequenting, but not burying, small carcasses, the following beetles were most common:

Staphylinidæ: *Silpha surinamensis* Fab., *S. lapponica* Hbst., *S. inaequalis* Fab., *S. noveboracensis* Forst. and *S. americana* L., *Staphylinus fossator* Grav., *Ontholestes cingulatus* Grav. and *Creophilus villosus* Grav.

Histeridæ: unidentified—at least three species, probably different genera.

Scarabæidæ: *Geotrupes blackburnei* Fab., *Onthophagus hecate* Panz., *O. orpheus* Panz., *O. nuchicornis* L.

Of these *Silpha noveboracensis* and *americana* and *Onthophagus hecate* were most numerous, coming both night and day, particularly to carrion which had deteriorated considerably. *Staphylinus fossator, Ontholestes cingulatus* and *Creophilus villosus* came to similar carcasses but chiefly in daylight hours. All of these species chewed at the bait. No evidence was obtained as to the food of the histerid species. None of these beetles was driven off by *Nicrophorus*, but only the histerids and *Onthophagus* remained if the carcass was buried.

Larvæ of *Silpha* usually come in small numbers to deteriorated carrion, and can be found many feet away heading toward the carcass with remarkable accuracy. The larvæ and adults of *Silpha* walk with a rapid, jerky movement. In the adults the jerks are more pronounced, possibly because the legs are longer. *Silpha* larvæ roll up like terrestrial isopod crustaceans ("sow bugs, pill bugs") and feign death, but the adults run away if disturbed.

Most of the carrion beetles (and dung beetles) carry a number of mites. *Nicrophorus* usually have less than twenty (*cf.* Leech, 1935). On arrival at carrion, many of the mites leave the beetles and may be found running about on the carcass and nearby ground. They hurry around on the body of the beetles and appear to share any agitation shown by the insect. Thus when the beetle is disturbed, the mites move much more extensively and leave the beetle much more frequently. The arrival of another beetle or irritation shown over some obstacle to burial is enough to greatly excite the mite population. The beetles were never seen to show any reaction to the presence or position of the mites, but it was noted also that the mites did not crawl out on the antennæ of the insects, although they ran over the mouthparts, dorsum, venter and leg bases. Schaupp's (1881) notes are interesting in suggesting a relationship between mites and the death of *Nicrophorus* pupæ.

Pukowski (1933) and Leech (1935) have followed in great

detail the later phases of the life history, subsequent to burial of the carcass. The present writers have not had opportunity to repeat many of these observations. They did note, however, that carcasses were cleaned fairly well of hair or feathers and worked into a compact ball, kept free of collected moisture, the skin remaining in fair condition while the tissues became a slate-gray, pasty mass, of a consistency similar to rotting dung. To see some of the later stages in the life cycle, two mice were laid on the top of four inches of earth and forest litter packed into a granite dish. Within a day, both mice were buried by pairs of *N. tomentosus*, and the dishful of carrion and insects was screened and carried home to Pennsylvania. Perhaps due to the agitation of the trip, the *Nicrophorus* came out of the ground and were observed running about over the soil, fluttering their wings and seeking an exit. Two of the four beetles (a pair) were caught and removed, and the remaining pair left to minister to any young they might have on the way. Soil moisture was maintained by occasional watering. The two beetles were seen running around a few times more, but on each occasion they returned into the earth. After two weeks one beetle was noticed on top of the ground, dead and eviscerated. The pan of carrion and earth was turned out on a paper. One mouse had dried to a hard mass. The second was in much better condition, and on it were two fat yellow larvæ of *N. tomentosus*, so distended with food that their intersegmental membranes were more conspicuous than the brown sclerites, and almost helpless to roll over and crawl away. The other parent (♀) was found dead among the earth. About two dozen fly puparia were among the soil particles, probably from the dried mouse. No further observations were made and the specimens were preserved for reference.

The foregoing observations were made during and between shots with the 16 mm. motion picture camera. A visual record in Kodachrome was obtained, somewhat over 600 feet in length, showing the carrying and plowing behaviors, the burial of several mice, the exhumation of mice and a snake, close-ups of *N. tomentosus* adults and larvæ, of *N. orbicollis*, including some footage made at night to the hum of misquitoes while *N. orbicollis* chewed through the string which held up the leg of a mouse. The present

notes on the burial behavior of *Nicrophorus* should fill in gaps left in the excellent work of Pukowski (1933) and Leech (1935) and with the film, allow entomologists more widely to become acquainted with the activities of this interesting genus.

ANNOTATED BIBLIOGRAPHY

ABBOTT, C. E. 1927*a*. Experimental data on the olfactory sense of Coleoptera, with special reference to the Necrophori. Annals Ent. Soc. Amer. 20: 207–216. Indicates olfactory sense located all over body of *Nicrophorus;* studied *N. americanus, orbicollis* and *tomentosus* from Md. in June.

———. 1927*b*. Further observations on the olfactory powers of the Necrophori. *Ibid.:* 550–553. Same in *orbicollis* in Wis. (July)

———. 1937. The necrophilous habit of Coleoptera. Bull. Brooklyn Ent. Soc., 32: 202–204. Indicates an obvious ecological succession of beetles, the kind of carrion determining the numbers and species involved.

BALDUF, W. V. 1935. The bionomics of entomophagous Coleoptera. (J. S. Swift Co., Inc.) Pp. 68–75. An excellent summary of the literature, particularly the work of Pukowski.

BELL, PROF. 1873. A glimpse of insect life. Can. Ent. 5: 94–95. Observed adult *Nicrophorus* removing maggots from a dead dog.

CLARK, C. U. 1895. On the food habits of certain dung and carrion beetles. Jour. N. Y. Ent. Soc. 3: 61. Mentions *Nicrophorus* feeding on maggots.

DAVIS, W. T. 1915. *Silpha surinamensis* and *Creophilus villosus* as predaceous insects. Jour. N. Y. Ent. Soc. 25: 150. Mentions *Nicrophorus* feeding on maggots from woodchucks and squirrels.

DUNCAN, C. D. AND G. PICKWELL. 1937. The world of insects. (McGraw-Hill Book Co.) Pp. 194. Indicates that *Nicrophorus* larvæ develop in a carcass before bacteria cause serious decomposition.

FABRE, J. H. 1899. Souvenirs entomologiques. VI. Pp. 113–153.

FOWLER, W. 1912. Coleoptera—General Introduction, Cicindelidæ and Paussidæ. Fauna Brit. India 1912: 12, 24. Discusses olfactory pits on antennæ, and indicates *Nicrophorus* as typical of temperate climates.

FURNEAUX, W. 1893. The outdoor world. (Longmans, Green & Co.) Pp. 141–143. Indicates that female *Nicrophorus* is first to settle on carcass, that male flies about, then both gorge selves on carrion, after which male buries carcass without help of female.

HATCH, M. H. 1927*a*. Studies on the Silphinæ. Jour. N. Y. Ent. Soc. 35: 331–371. Primarily a taxonomic paper, indicating *Nicrophorus* as the spelling used by Fabricius in erecting the genus.

———. 1927*b*. Studies of carrion beetles of Minnesota, including new species. Univ. Minn. Agric. Exp. Sta. Tech. Bull. 48: 3–7.

———. 1940. Observations on Silphinæ, with a note on intraspecific variations and their designation. Jour. N. Y. Ent. Soc. 48: 233–244.

JAQUES, H. E. 1915. The fish feeding Coleoptera of Cedar Point. Ohio Nat. 15: 525–528. Indicates *Nicrophorus* feeding on fish washed ashore.

LEECH, H. B. 1935. The family history of *Necrophorus conversator* Wlk. Proc. Ent. Soc. B. C. 31: 36–40. The most complete life history study of a North American species.

LUTZ, F. E. 1921. Fieldbook of insects. (G. P. Putnams Sons.) Pp. 295–296. Cites *N. americanus* as preferring reptiles, but indicates no burying beetles came to any bait set out under experimental conditions.

MILNE, L. J. 1928. Notes on Silphidæ in Haliburton County, Ontario. Can. Field Nat. 42: 43. Earlier observations on burying behavior.

MORLEY, R. L. 1902. Notes on stridulation. Ent. Mo. Mag. 38: 249–250. Indicated that abdomen was rubbed on elytra to produce noise, and coxæ play no part in *N. moratorium*.

MOTTER, M. G. 1898. A contribution to the study of the fauna of the grave. Jour. N. Y. Ent. Soc. 6: 201–231. Indicates no *Nicrophorus* on disinterred corpses (*cf.* Wood, 1873).

PUKOWSKI, ERNA. 1933. Oekolokische Untersuchungen an *Necrophorus* F. Zeits. Morph. Okol. Tiere 27: 518–586, 25 figs., refs. The most complete account of the life history of European species of *Nicrophus*, including references to the European literature.

SCHAUPP, F. G. 1881. Description of the larva of *Necrophorus tomentosus* Web. Bull. Brooklyn Ent. Soc. 4: 37–38. Indicated that mites killed 50 per cent of *Nicrophorus* pupæ by sucking them dry.

SELOUS, C. F. 1911. A preliminary note on the so-called carrion-feeding Coleoptera. Ent. Mo. Mag. 47: 86–89. Beetles flew into wind, walking last few feet to carrion, dragged carcasses to softer earth. Not convinced that *Nicrophorus* are feeders on carrion, probably predators.

STEELE, B. F. 1927. Notes on the feeding habits of carrion beetles. Jour. N. Y. Ent. Soc. 35: 77–81. Indicated *N. orbicollis* and *tomentosus* ate maggots from a woodchuck, and preferred maggots to carrion.

THOMSON, SIR J. A. 1935. Biology for everyman. (E. P. Dutton.) Vol. 2: 866–867. Brief summary of life history.

WOOD, J. G. 1873. Insects at home. (Wm. Rutter.) Pp. 86–93. Indicates *Nicrophorus* attack poorly interred human bodies in Russia. Found sex ratio about 1: 1. Other observations correspond to those of Furneaux, but more extended.

THECLA BURDI KAYE, A SYNONYM

BY E. IRVING HUNTINGTON

W. J. Kaye described *Thecla burdi* from St. Vincent, B.W.I., in "The Entomologist," vol. 56, p. 277, 1923. In the collections of the American Museum of Natural History there is a large series of *Thecla angerona* Godman and Salvin from Canefields, Dominica, B.W.I., collected by Mr. L. E. Chadwick between October 24, 1933, and January 16, 1934, as well as three females from Roseau, Dominica, taken on October 19–20, 1933, by the same collector; in addition to this series there are one male and two females taken on the type locality island of St. Vincent by Mr. E. B. Isaacs, and one male taken at Brimstone Hill, St. Kitts, B.W.I., March 16, 1929, collector E. I. Huntington. This series has been compared with Kaye's original description and there can be no doubt that the insect described by Kaye as *Thecla burdi* is the same as that described by Godman and Salvin as *Thecla angerona* (Proc. Zool. Soc., London, p. 516, 1896).

Through an oversight, this synonomy was not referred to in "Lycænidæ of the Antilles," Comstock and Huntington (Ann. New York Acad. Sci., vol. 45, p. 76).

A NEW SPECIES OF LAMBDINA, AND NOTES ON TWO SPECIES OF BESMA (LEPIDOPTERA, GEOMETRIDÆ, ENNOMINÆ)

BY LAURENCE R. RUPERT
HORSEHEADS, N. Y.

Recent study of various species of the group of the *Geometridæ,* until recently known as the genus *Ellopia,* has disclosed an apparently undescribed species of *Lambdina* Capps, and sufficient difference between *Besma quercivoraria* Gn. and *B. endropiaria* G. & R., to warrant retention of both these names at specific rank. A description of the new species and notes on the other two follow.

Lambdina canitiaria new species

Similar to *athasaria* Wlk., in shape, color, and maculation of wings; head dark gray, showing no trace of the yellow that is so conspicuous in *athasaria;* thorax and abdomen dark gray, much less yellow than in *athasaria;* male antennæ more narrowly pectinate than in *athasaria.* (The longest pectinations are about 1 mm. long, while in *athasaria* they average 1¾–2 mm. long.) Male genitalia similar to those of *athasaria* but with slight differences which may not prove constant when a longer series of *canitiaria* is available. I have examined the genitalia of two males of *canitiaria,* and of twelve males of *athasaria.* The *canitiaria* genitalia both differ from any *athasaria* examined and from the figures shown by Capps (Proc. U. S. N. M., Vol. 93, Plate 3), in having (1) finer and shorter spinules on the furca, and fewer of them along the basal third; (2) the terminal part of the furca wider and more rounded; and (3) the auger-like process at the end of the ædeagus less prominent.

Wing expanse 1–1¼ inches, averaging a little smaller than *athasaria.*

At Horseheads, N. Y., the only locality from which it is known, *canitiaria* is the earliest *Lambdina* to appear in the spring. It is on the wing about three weeks earlier than *athasaria* and the periods of flight of the two species have not been observed to overlap in the same season.

Holotype.—♂, Horseheads, N. Y.—May 22, 1940. (In Franclemont collection.)

Allotype.—♀, Horseheads, N. Y.—May 4, 1938. (In Rupert coll.)

Paratypes.—3 ♂♂, Horseheads, N. Y.—May 22, 1940, and May 9, 1943. (In Rupert coll.)

Besma quercivoraria Gn.—Two females were taken at Horseheads in May 1943. Eggs were obtained from both, and larvæ from both lots were raised to maturity. No differences of note were observed among the eggs, larvæ, and pupæ of the two lots.

The eggs were elliptical, with the surface finely and evenly pitted, at first translucent, almost colorless, but with a faint greenish tinge, which soon became darker and more distinctly green.

The young larvæ were pale yellow green, very slender and very active. They accepted as food several species of oak, but refused everything else offered including maple. Beech was not readily available, and was not offered at this time. On June 22, when most of the larvæ were in the last stage, I left Horseheads to spend several weeks at Sardinia, N. Y., where oak is difficult to find. The larvæ then accepted beech readily, but still refused maple.

The mature larvæ were dull light yellow-green, with head somewhat mottled with brown; second thoracic segment with two prominent brown lateral warts but no conspicuous dorsal adornment; first, second, third, fifth, and sixth abdominal segments with inconspicuous lateral warts; third and sixth abdominal segments each bearing in addition to the lateral warts two prominent subdorsal warts, those on segment 3 somewhat fused with each other, and with the lateral warts of this segment; other segments without special prominences.

The larvæ pupated in late June and early July, forming pale brown pupæ, with wing cases streaked, and abdomen heavily speckled with dark brown. All of the pupæ produced moths the same season, mostly between July 9 and 25, but with a few stragglers in August, September, and October.

Besma endropiaria G. & R.—A female of this species was taken at Sardinia, N. Y., on June 27, 1943, but only fifteen eggs were obtained. These were similar in size, shape, and surface texture to those of *quercivoraria,* but lacked the green tinge, and showed no color change except the normal darkening just before hatching. They hatched on July 9, the same day that produced the first adult of *quercivoraria* as noted above.

The young larvæ were similar in appearance to those of *quercivoraria,* but the only food they would accept was maple. They refused beech, but were not offered oak since it was not readily available. This preference for maple was not unexpected, for several years ago a single larva which I found upon maple produced a male of this species, which I still have in my collection.

The mature larvæ were either green or brown, with head more uniform brown and less mottled than in *quercivoraria;* second thoracic segment with lateral and subdorsal warts so fused as to form a conspicuous ridge extending completely from one lateral wart to the other; first and second abdominal segments with warts similar to those of *quercivoraria,* and in addition a ventral prominence on the second segment; third abdominal segment with warts similarly placed to those of *quercivoraria,* and similarly fused, but larger; fifth abdominal segment with two well-developed subdorsal warts, somewhat fused with each other, but not with the lateral ones; sixth abdominal segment with warts similar to those of the fifth segment.

Of the thirteen larvæ reared, seven were green with brown warts, similar in color to *quercivoraria* larvæ, while the rest were dull brown with darker brown warts. It is reasonable to suppose that a brown form of the larva of *quercivoraria* may occur.

The larvæ pupated in late August, producing pupæ much darker than those of *quercivoraria.* This color difference may not be constant in large series, however, for it has been noted that among certain other *Geometridæ* the pupæ as well as the larvæ exhibit two or more color phases. These pupæ produced no moths until the following season. The failure of *endropiaria* to produce two generations a season is in accordance with the results of field collecting at Ithaca, Horseheads, and Sardinia, N. Y. (Franclemont and Rupert), and at Chicago, Ill. (Wyatt). At Ithaca, Horseheads, and Chicago both species occur, with *endropiaria* flying between the two broods of *quercivoraria.* At Sardinia *endropiaria* flies in June and *quercivoraria* has never been taken.

In addition to the differences noted above between these two species, there appears to be a constant difference in the male antennæ. This was first called to my attention by Dr. Forbes,

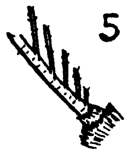
and I have since confirmed his observation by examining all the males of both species in my collection. In *quercivoraria* the length of the pectinations shows a very gradual increase from each segment to the next from the base of the antenna, while in *endropiaria* this increase is more abrupt. Likewise the decrease in length of pectinations near the tip is correspondingly gradual in *quercivoraria* and abrupt in *endropiaria*. In general the pectinations are slightly shorter even at the middle of the antennæ in *quercivoraria*.

Considering altogether the differences found between these two species in egg, larval structure and food, period of flight and number of generations a year, and structure of male antennæ, along with the well-known differences in the appearance of the adults, it seems quite reasonable to consider them distinct species, even though the genitalia show no obvious differences. It is true, as Mr. Capps points out (Proc. U. S. N. M., Vol. 93, p. 142), that apparent intergrades occur. However, if only one species is involved, it would seem that such intergrades should be more commonly found than they are in localities where the typical forms are both abundant. Intermediate specimens have never been taken at Horseheads, nor, so far as I can discover, at Ithaca, where intensive collecting over a period of many years has produced large series of both regular forms.

PLATE XI

Figure 1. ***Besma quercivoraria*** **Gn. Larva.**
Figure 2. ***Besma endropiaria*** **G. & R. Larva.**
Figure 3. ***Lambdina canitiaria*** **new species. Furca of male genitalia.**
Figure 4. ***Lambdina athasaria*** **Wlk. Furca of male genitalia.**
Figure 5. ***Besma quercivoraria.*** **Base of male antenna, showing only the first five pectinations, and only those on one side.**
Figure 6. ***Besma endropiaria.*** **Similar view of part of male antenna.**

1-QUERCIVORARIA



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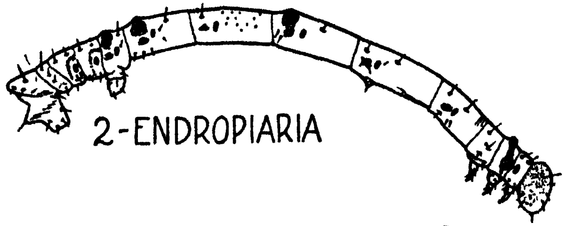
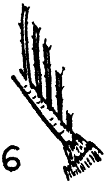
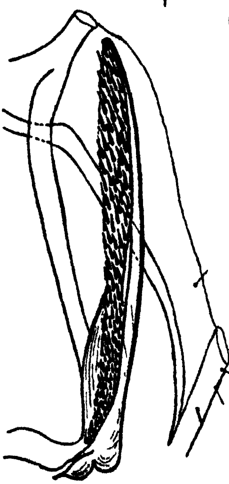


2-ENDROPIARIA



6

3-CANITIARIA



4-ATHASARIA

PSYLLIIDÆ FROM TROPICAL AND SEMITROPICAL AMERICA (HOMOPTERA)*

BY JOHN S. CALDWELL
CIRCLEVILLE, OHIO

Much of this material consists of species set aside and studied over a period of time because many are not generically distinct, that is they possess characters common to more than one genus according to the present interpretations. Rather than attempt to revise several genera which would be no more than my personal interpretation and quite artificial, I believe the true nature of the generic situation may be represented by a series of frequency curves with the generic types and closely related species near the crown, and the less related species farther down the curves. This way it seems possible that two species belonging in separate genera may be very closely related, which is the true situation at present between *Rhinopsylla* and *Kuwayama*.

The writer takes this opportunity to express his appreciation to Miss Louise M. Russell of the U. S. Department of Agriculture for comparing much of this material with specimens in the D. L. Crawford collection. Dr. Leonard Tuthill has kindly examined some of this material and expressed his opinion concerning its validity. Unless stated to the contrary all types are in the writer's collection.

Calophya arcuata new species, (Fig. 5)

Length 2 mm., forewing 1.7 mm. Deep orange over all with black eyes and genæ and yellow legs.

Head broad. Vertex smooth, impressed discally making posterior ocelli greatly elevated; cephalic half rounded downward and forward. Genæ widely separated, acute, one-third as long as vertex. Thorax scarcely arched; pronotum as long as vertex, deflexed, appearing tricarinate. Membrane of forewing minutely rugose; pterostigma long, open at base; Rs long; M highly arched around large cubital cell.

* Zoologically speaking, *Chermes alni* L., 1758, is the same insect now known as *Prociphilus tessellatus* (Fitch) [Data from Pehr Kalm, 1756]; hence Kirkaldy's *Psyllia*, type *pyri* L., is the type genus of the family Psylliidæ.

Female genital segment as long as rest of abdomen; dorsal valve bulbose in basal half, apical half deflexed, extreme apex acute; ventral valve subequal in length to dorsal.

Holotype: female from Bonefish Key, Florida, 2-24-40 (Caldwell).

Kuwayama striata new species, (Fig. 6)

Length 2.5 mm., forewing 2.1 mm. Greyish-yellow species with four prominent red stripes on mesoscutum.

Vertex rather small, flat, somewhat rounded in front. Genæ subspherical. Prescutum as long as broad, longer than scutum, rounded cephalad. Forewings three times as long as broad, Rs reaching as far as furcation of M.

Female genital segment three-fourths as long as rest of abdomen; dorsal valve straight dorsad, suddenly blunted apically; ventral valve somewhat stylate in apical fourth.

Holotype: female from Saltillo, Coahuila, 9-23-41 (DeLong, Good, & Caldwell).

Kuwayama hyalina new species, (Fig. 2)

Length 2.9 mm., forewing 2.3 mm. Yellow over all with black eyes. Wings very milky white, hyaline.

Vertex scarcely deflexed, short, emarginate caudad; foveæ shallow. Genæ roundly swollen. Clypeus visible from front but not prominent. Pronotum nearly vertical; prescutum flat dorsad, acute cephalad. Forewings two and a half times as long as broad, not especially acute apically; Rs reaching to furcation of M.

Female genital segment abruptly styliform in apical half; anal opening located well caudad on dorsal valve.

Female holotype and paratype from Tasquillo, Hidalgo, 10-24-41, Km. 172 (DeLong & Good).

Kuwayama mexicana new species, (Fig. 1)

Length 4 mm., forewing 3 mm. Vertex cream excepting elongate foveæ. Pronotum cream; thoracic dorsum red with light cream median stripe. Antennæ, legs and abdomen black.

Robust species. Vertex relative horizontal, flat. Eyes prominent. Genæ produced into minute cones, blunt. Antennæ twice as long as width of head. Pronotum small, depressed to level of vertex; prescutum high, acute cephalad; scutum short. Forewings large, over twice as long as broad, not acute. Hind wings small, not reaching to furcation of M in forewings. Pubescence prominent on legs.

Forceps of male simple, slender, as long as proctiger.

Holotype: male from Mexico, D. F., west 18 Kms., 9–1–39 (DeLong).

Kuwayama lateralis new species, (Fig. 3)

Length 3.5 mm., forewing 2.7–3 mm. General color grey with faint red laterally on prescutum and scutum. Venter of head and thorax black to dusky. Abdomen black dorsad, dusky ventrad with light lateral stripe on either side for full length.

Vertex deflexed, foveæ deep, ocelli raised. Antennæ twice as long as width of head. Genæ swollen. Thorax rather flat, not robust. Forewings almost three times as long as broad.

Proctiger of male longer than forceps. Forceps produced on cephalic margins at midlength. Female genital segment almost as long as rest of abdomen; dorsal valve straight, somewhat styliform apically; ventral valve abruptly styliform in apical third.

Male holotype, female allotype, and paratypes from Mexico, D. F., west Km. 20, 11–24–38 (Caldwell).

Trioza rhinosa new species, (Fig. 4)

Length 4.5 mm., forewing 3.5 mm. Shining black over all with white genæ.

Head broad; eyes prominent; postocular areas large. Vertex sloped inward toward median line, rolled roundedly forward; medial ocellus prominent. Genal cones acute, divergent, one-fourth as long as vertex. Pronotum vertical; rest of thorax scarcely arched. Femora prominent, metatibiæ with apical spur ratio of 3–1. Forewings twice as long as broad, rounded; cubital cell smaller than medial; Rs scarcely separated from and paralleling M in basal fourth.

Forceps of male slender, incurved in caudal aspect. Proctiger long, broad in lateral aspect.

Holotype: male from Tehuacan, Puebla, 10–17–41 (DeLong, Good, Caldwell, & Plummer).

The peculiar formation of the head and forewings places this species close to the *Rhinopsylla*. In general appearance it is close to *T. diospyri* Ashm.

Metatrioza neotriozella new species

Length 2.5–2.7 mm., forewing 2–2.2 mm. Head and genal cones black. Mesonotum with red center and two black stripes on either lateral margin. Costal margin of forewing black basally.

Head as broad as thorax. Vertex strongly concave between eyes, median suture prominent. Genal cones slender, as long as vertex, closely appressed. Antennæ scarcely as long as width of head. Thorax scarcely arched. Forewings almost three times as long as broad. Hind tibiæ with three closely appressed spurs at apex.

Forceps of male of even width throughout, truncate apically, evenly arcuate in caudal aspect.

Dorsal valve of female genital segment styliform in apical half, inflated in basal half; ventral valve somewhat styliform.

Male holotype, female allotype, and paratypes from Tucson, Arizona, 8–16–40, (D. J. & J. N. Knull) are in the Ohio State University collection at Columbus, Ohio.

Except for the unique form of the vertex this species would belong in *Neotriozella* Crawford.

Optomopsylla new genus

Head including eyes much broader than pro and mesonotum, as broad as metathorax. Vertex smooth except for median groove, vertical, rounded gently caudad. Posterior ocelli projecting laterad, almost touching the compound eyes. Pronotum much sunken below level of mesonotum and vertex. Propleurites much compressed, somewhat transversely concave. Forewings with Cu branched from main stem before R and M.

Related to *Ceropsylla* but differentiated by the structure and form of head and thorax.

Type: **Optomopsylla formiciformis** n. sp.

Optomopsylla formiciformis new species, (Figs. 7, 7–A & 7–B)

Length 3.5 mm., forewing 3.1 mm. Black with the exception of basal four-fifth of antennæ, lateral and ventral portion of pro and mesothoracic femora, all of metathoracic legs, venter of abdomen and genital segment, most of mesothorax, scutum of mesothorax and dorsum of metathorax whitish. Forewings clear with R+M+Cu and R heavily darkened.

Genal cones heavy, blunt, divergent, almost as long as vertex. Head vertical. Thorax scarcely arched, flat in profile; pronotum greatly depressed. Metatibiæ with apical spur ratio of 3–1. Forewings three times as long as broad, acute; cubital cell long, flat.

Female holotype from Zamora, Michoacan, 10–2–41 (DeLong, Good, Caldwell, & Plummer), on willow.

The form combined with the deceptive markings gives this psyllid the appearance of a black ant in dorsal or lateral aspect. The genæ appear as mandibles, the fore part of the thorax is much narrowed and the color on the last thoracic segment and base of the abdomen form the optical illusion of a narrow waist. The metathoracic legs are white and scarcely visible but the heavily embrowned vein in the forewings completes the illusion of a walking leg. This specimen was swept from willow along

with a net full of ants about the same size. Whether accidental or not, to me this is a remarkable example of mimicry.

Euphalerus dubius new species, (Fig. 9)

Length 4 mm., forewing 3 mm. General color green variegated with gray. Head as broad as thorax, almost perpendicular. Vertex twice as broad as long, flat, median suture very smooth. Genal cones scarcely differentiated from vertex, short, blunt, contiguous on basal third. Antennæ one and a half times as long as width of head. Thorax strongly arched, very smooth, sutures very fine between thoracic segments and between head and pronotum. Pleurites of prothorax subequal. Forewings long, somewhat rhomoboidal; pterostigma long and broad.

Female genital segment as long as rest of abdomen.

Female holotype from Davis Mts., Texas, 7–2–40 (D. J. & J. N. Knull). Type in Ohio State University collection at Columbus, Ohio.

Psyllia martorelli new species, (Figs. 8 & 8–A)

Length 2.5–3.5 mm., forewing 2–2.5 mm. Specimens in preservative color unknown. Mesoscutum with broad light stripes.

Head broader than thorax; eyes somewhat stalked; posterior ocelli greatly elevated. Vertex scarcely deflexed, rolled somewhat roundedly forward. Genæ scarcely swollen; frons much sunken but not covered by genæ. Antennæ almost as long as entire insect. Thorax scarcely arched. Forewings little over twice as long as broad; apical margins almost flat; pterostigma not apparent; costal margins pubescent.

Apices of male forceps slightly bifurcate. Female genital segment as long as rest of abdomen; both valves very slender, stylate in apical half.

Holotype male, allotype female, and paratypes from Villalba, Puerto Rico, May 1940, on "Inga Inga" (L. F. Martorell).

This species shows some relationship to the *Pauropsyllinæ*.

The writer dedicates this outstanding species to his friend Dr. Luis F. Martorell.

Psyllia berryi new species, (Figs. 11 & 11–A)

Length 5.4 mm., forewing 4.4 mm. Greenish-yellow over all.

Vertex very small, cephalic margin compressed between genæ. Genæ greatly developed, larger than vertex, inner margins contiguous, apices blunt. Antennal insertion in front of ventral margins of eyes. Eyes very small; postocular area large. Pronotum strongly descending, prominent; prescutum rounded, longer than scutum. Forewings almost three times as long as broad; pterostigma very narrow, elongate; cubital cell twice as large as medial.

Female genital segment short; dorsal valve rounded, somewhat bulbose apically; anal opening with serrate margins; ventral valve short, thick.

Female holotype from Santaram, Para, Brazil, October 1942 (L. A. Berry).

The gigantic development of the genæ sets this species apart from any psyllid known to me; however, the structure of the entire insect is true to the genus. Too many of the present genera of Psylliidæ have been established on gradational characters for me to add another when there are no fundamental differences on which to base a decision.

The writer takes great pleasure in naming this unique species in honor of his friend Lawrence A. Beery, Jr.

Psyllia cedusa new species, (Fig. 10)

Length 2.5 mm., forewing 2.1 mm. General color orange-yellow. Forewings with four black marginal spots.

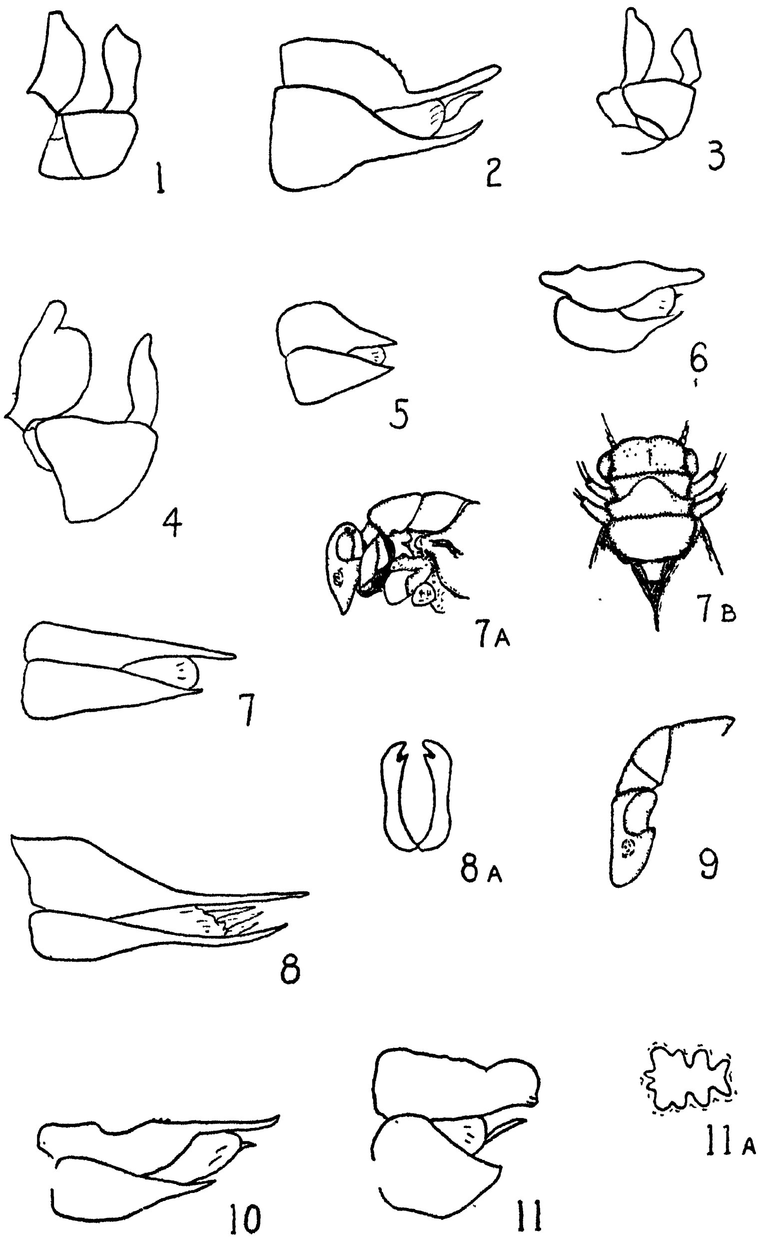
Vertex twice as broad as long; foveæ sharp, deep; posterior ocelli greatly elevated. Genal cones three-fourths as long as vertex, divergent. Whole head deflexed, as broad as thorax. Thorax not especially arched yet pronotum is nearly vertical. Hind tibiæ with small basal spur. Forewings little over twice as long as broad; cubital cell very highly arched; pterostigma, small, equilaterally triangular.

Female genital segment as long as rest of abdomen; dorsal valve straight, stylate in apical third with apex turned up; ventral valve narrowed in apical half, curved dorsad.

Female holotype from Jesus Carranza, Veracruz, 10–14–41 (DeLong, Good, Caldwell, & Plummer).

PLATE XII

Figure 1. *Kuwayama mexicana.* Lateral view of male genitalia.
Figure 2. *Kuwayama hyalina.* Lateral view of female genitalia.
Figure 3. *Kuwayama lateralis.* Lateral view of male genitalia.
Figure 4. *Trioza rhinosa.* Lateral view of male genitalia.
Figure 5. *Calophya arcuata.* Lateral view of female genitalia.
Figure 6. *Kuwayama striata.* Lateral view of female genitalia.
Figure 7. *Optomopsylla formiciformis.* Lateral view of female genitalia.
Figure 7–A. Profile of head and thorax.
Figure 7–B. Dorsal view of head and thorax.
Figure 8. *Psyllia martorelli.* Lateral view of female genitalia.
Figure 8–A. Caudal view of male forceps.
Figure 9. *Euphalerus dubius.* Profile of head and thorax.
Figure 10. *Psyllia cedusa.* Lateral view of female genitalia.
Figure 11. *Psyllia beeryi.* Lateral view of female genitalia.
Figure 11–A. Dorsal view of circum-anal ring.


1
2
3
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7A
7B
7
8A
9
8
10
11
11A

NOTES ON MEXICAN BUTTERFLIES, IV

BY F. MARTIN BROWN

NYMPHALIDÆ—I

Heliconiinæ

230. **Heliconius ismenius telchinia** Doubleday.
    G. & S. (1), **1**: 149, 667.
    S. (2), p. 380, pl. 72b.
    H. (3), p. 672.
    Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ v.12.41 (R.P.).

237. **Heliconius petiverana** Doubleday & Hewitson.
    G. & S., **1**: 153, 668.
    S., p. 392, pl. 78b.
    H., p. 673.
    El Bañito Valles, San Luis Potosi, 200 ft., 3 ♂♂ vii.22.39; 1 ♂ 1 ♀ iv.28–29.40 (H.H.).
    El Pujal, San Luis Potosi, 100 ft., 2 ♂♂ 2 ♀♀ vii.18–20.39 (H.H.).
    Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ v.12.41 (R.P.).
    Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ 1 ♀ v.10.41 (R.P.).
    El Sabino, Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

The broad red bar on the forewings of the Vera Cruz specimens is more rosy red than on the San Luis Potosi specimen. On the latter the bar is tomato red. Is this a real difference or one due to the age of the specimen? In each of the above series there are fresh and flown specimens; females seem to be smaller and more worn than the males.

238. **Heliconius charithonia** Linnæus.
    G. & S., **1**: 151.
    S., p. 394, pl. 79a.
    H., p. 673.
    Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1600 ft., 3 ♂♂ 1 ♀ vi.16–20.40 (H.H.).

nr. Villagran, Tamaulipas, 1 ♂ 1 ♀ iv.28.41 (R.P.).
60 mi. So. of Victoria, Tamaulipas, 1 ♂ vii.6.36 (H.D.T.).
Jacala, Hidalgo, 4500 ft., 1 ♂ vi.29.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 4 ♂♂ 6 ♀♀ v.28–29.41 (R.P.).
El Mante, San Luis Potosi, 1 ♂ iv.29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♂ 1 ♀ vii.22.39, 2 ♂♂ 2 ♀♀ vi.26–27.40 (H.H.); 1 ♀ iv.31.41 (R.P.).
El Pujal, San Luis Potosi, 100 ft., 3 ♂♂ 1 ♀ vii.17–31.39 (H.H.).
Tuxpango, Vera Cruz, 1500 ft., 1 ♀ v.9.41 (R.P.).
Fortin, Vera Cruz, 1600 ft., 4 ♂♂ v.3.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ 4 ♀♀ v.12.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 1 ♂ 1 ♀ v.6.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.).
Acahuato, Michoacan, 3000 ft., 1 ♂ viii.2.40 (H.H.).

All of the females show a distinct rusty flush over the yellow bars, it is most intense toward the margins. Among these specimens the females seem to be more worn than the males.

243. **Eueides aliphera gracilis** Stichel.
G. & S., 1: 163, 669 (as *aliphera*).
S., p. 399.
H., p. 673.
Tuxpango, Vera Cruz, 1500 ft., 1 ♀ v.9.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♀ v.12.41 (R.P.)

244. **Eueides cleobæa zorcaon** Reakirt.
G. & S., 1: 165, 670.
S., p. 368.
H., p. 674.
Galeana, Nuevo Leon, 6500 ft., 2 ♂♂ 1 ♀ iv.29.41 (R.P.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 4 ♂♂ v.29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ 3 ♀♀ vii.22.39; 1 ♂ 1 ♀ vi.28.40 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 1 ♂ 3 ♀♀ vii.12–21.39 (H.H.).

Fortin, Vera Cruz, 1500 ft., 1 ♂ v.3.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 3 ♂♂ 3 ♀♀ v.10.41 (R.P.).

There is considerable variation in this species. The ground color varies from rich fulvous brown to faun. The apical light spots are either concolorous with the rest of the wing or lighter. Seitz (*l.c.*) states that in the females these spots are "rather pale yellow." They do tend to be lighter in the females but yellow apical spots are not restricted to females nor do all females have yellow spots.

There is a peculiar variation in the color of the antennæ. The females have antennæ that are almost wholly yellowish. The males have dark antennæ that are yellow tipped.

Dioninæ

246. **Dryas julia delila** Fabricius.
G. & S., **1**: 168, 670.
S., p. 400.
H., p. 674.
60 mi. So. of Victoria, Tamaulipas, 1 ♀ vii.6.36 (H.D.T.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 15 ♂♂ v.28–29.41 (R.P.).
Arroyo del Calabezas, San Luis Potosi, 250 ft., 1 ♂ iv.30.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 3 ♂♂ 1 ♀ vii.22.39 (H.H.); 1 ♂ iv.30.41 (R.P.).
El Pujal, San Luis Potosi, 100 ft., 3 ♂♂ vii.17.39 (H.H.).
Fortin, Vera Cruz, 1600 ft., 1 ♂ v.3.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♀ v.12.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 6 ♂♂ v.10.41 (R.P.).
El Sabino, Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

The black apical streak, characteristic of *julia* is present in a reduced fashion on males from El Sol, El Bañito, El Pujal and Rio Blanco, and on both females.

248. **Dione juno huscama** Reakirt.
G. & S., **1**: 170, 670 (as *juno*).
S., p. 401, pl. 84e.

H., p. 674.
Galeana, Nuevo Leon, 6500 ft., 2 ♂♂ iv.29.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 1 ♀ vi.21.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 6 ♂♂ 1 ♀ v.28–29.41 (R.P.):
El Sabino, Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).
Tancitaro, Michoacan, 6000 ft., 1 ♂ 1 ♀ vii.20.40 (H.H.).

In general all of these are more boldly marked with black than Seitz' figured specimen but not quite so boldly as his figure of *juno juno.* The El Sol series is reasonably fresh; the others are worn.

249. **Dione vanillæ** Linnæus.
G. & S., **1**: 171, 671.
S., p. 401, pl. 84f.
H., p. 674 (as *v. insularis* May).
Jacala, Hidalgo, 4500 ft., 4 ♂♂ 3 ♀♀ vi.15–vii.3.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ v.29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ vii.22.39 (H.H.).
Tuxpango, Vera Cruz, 1500 ft., 1 ♂ v.8.41 (R.P.).
Rio Balsas, Guerrero, 2400 ft., 1 ♂ v.26.41 (R.P.).
Apatzingan, Michoacan, 1050 ft., 1 ♀ viii.5.40 (H.H.).
El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).

None of these specimens is *insularis;* all have fully developed markings along the margins of the hindwings. The males of the Jacala series lack the small black dot between M_3 and Cu_1 close to the cell on the hindwings. This dot is present on all of the other males and on all of the females.

NYMPHALINÆ

Tribe **Argynnidi**

251. **Euptoieta claudia** Cramer.
G. & S., **1**: 174, 671.

S., p. 403, pl. 85a.
H., p. 674.
Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 1000 ft., 1 ♀ vi.14.40 (H.H.).
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1600 ft., 2 ♂♂ 1 ♀ vi.16–18.40 (H.H.).
60 mi. So. of Victoria, Tamaulipas, 1 ♂ vii.6.36 (H.D.T.).
Galeana, Nuevo Leon, 6500 ft., 1 ♂ viii.3.39 (H.H.).
Jacala, Hidalgo, 4500 ft., 2 ♂♂ vi.25.39 (H.H.).
El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ 1 ♀ vi.27–28.40 (H.H.).
Tuxpango, Vera Cruz, 1500 ft., 1 ♀ v.9.41 (R.P.).
Chichen Itza, Yucatan, 1 ♀ viii.30.36 (H.D.T.).
Rio Balsas, Guerrero, 2400 ft., 1 ♀ v.26.41 (R.P.).
El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).
Tancitaro, Michoacan, 6600 ft., 1 ♀ viii.14.40 (H.H.).

This is probably one of the most adaptable of American butterflies. I have found it breeding from sea-level in the tropics to 11,800 ft., in the lower margin of the alpine-arctic zone in Colorado. In that state it is not uncommon far above tree line, at 13,000 ft. or more. I feel that this species is a true archaic ancestor of the genus *Argynnis*. I know of no structural differences between *Euptoieta* and *Argynnis* that are of generic value.

The species *claudia* is also found in the South Temperate Zone. I can find no reliable character to separate material from the Argentine (*hortensia* Blanchard) from the material before me. In this respect the two forms are analogous to *Phœbis eubule* and *amphitrite*.

252. **Euptoieta hegesia** Cramer.
G. & S., 1: 175, 671.
S., p. 404, pl. 85a.
H., p. 674.
Sabinas Hidalgo, Nuevo Leon., 900 ft., 1 ♂ vi.15.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ iv.31.41; 2 ♂♂ 1 ♀ v.29.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♀ vii.21.39; 3 ♂♂ 1 ♀ vi.28.40 (H.H.).
Fortin, Vera Cruz, 1600 ft., 1 ♀ v.4.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 2 ♂♂ v.6.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ 1 ♀ v.10.41 (R.P.).
Chichen Itza, Yucatan, 2 ♂♂ 1 ♀ viii.30.36 (H.D.T.).
Rio Blanco, Guerrero, 2400 ft., 1 ♀ v.26.41 (R.P.).
Sta. Lucrecia, 2 ♂♂ 1 ♀ iv.24.39 (H.D.T.).
Acahuato, Michoacan, 3000 ft., 1 ♂ viii.2.40 (H.H.).
El Sabino, Uruapan Michoacan, 1 ♂ 1 ♀ vii.15–30.36 (H.D.T.).

266. **Melitæa definita** Aaron (?).
G. & S., **2**: 676, pl. 108, ff. 11, 12 (as *schausi*).
S., p. 433 (p. 434, pl. 88h, as *schausi*).
H., p. 676.
Cuidad Victoria, Tamaulipas, 1 ♂ vi.19.39 (H.H.).
Jacala, Hidalgo, 4500 ft., 1 ♂ vi.24.39 (H.H.).

These two specimens come fairly close to Texan *definita* but are by no means typical. The upper side gives the impression that they are *Euphydryas* and the underside continues the impression. I suspect that this is a paleonearctic species and may be closely related to the archaic species from which our North American *Euphydryas* have sprung. The Jacala specimen extends the known range of the species.

270. **Melitæa theona** f. **theona** Ménètries.
G. & S., **1**: 192, **2**: 677 (as *Phyciodes*).
S., p. 438, pl. 89g (as *Phyciodes*).
Ha. (4), p. 26 (as *Phyciodes*).
H., p. 676.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 2 ♂♂ vi.15–16.40 (H.H.).
Galeana, Nuevo Leon, 6500 ft., 1 ♂ iv.29.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 2 ♂♂ 1 ♀ vi.19–vii.3.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 4 ♂♂ 3 ♀♀ iv.31; v.29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♀ vii.22.39; 1 ♀ vi.26.40. (H.H.); 1 ♂ iv.30.41 (R.P.).

270a. **Melitæa theona f. thekla** Edwards.

G. & S., **2**: 677 (as *theona*).
S., p. 433, pl. 88f.
Ha., p. 26 (as *Phyciodes theona* in part).
H., p. 676.
Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 1500 ft., 1 ♂ vi.14.40 (H.H.).
Las Adjuntas, Nuevo Leon, 3000 ft., 1 ♂ vi.21.40 (H.H.).
Arroyo del Meco, Tamaulipas, 1520 ft., 1 ♀ iv.28.41 (R.P.).

——. **Melitæa** sp.

Two battered specimens of the *gabbi* group were taken by Potts, Cumbres, Vera Cruz, 8000 ft., v.17.41, and Rio Balsas, Guerrero, 2400 ft., v.26.41.

272. **Phyciodes elada elada** Hewitson.

G. & S., **1**: 196, **2**: 679, pl. 21, ff. 6, 7.
S., p. 437, pl. 89f.
Ha., p. 19.
H., p. 676 (as *Melitæa*).
Cumbres, Vera Cruz, 8000 ft. (nr. Km. 295) 1 ♂ v.7.41 (R.P.).
Apatzingan, Michoacan, 1050 ft., 2 ♂♂ viii.3–5.40 (H.H.).
Acahuato, Michoacan, 3000 ft., 2 ♂♂ viii.2.40 (H.H.).

The two Acahuato specimens are much larger than the two from Apatzingan. The baso-apical radii of the forewings are 15.0, 14.2 and 12.5, 12.0 mm. respectively. The Cumbres specimen may not be properly placed here, Hoffmann records the species only from the west coast.

272a. **Phyciodes elada callina** Boisduval.

Ha., p. 20.
Sabinas Hidalgo, Nuevo Leon, 960 ft., 1 ♂ vi.15.39 (H.H.).
Jacala, Hidalgo, 4500 ft., 10 ♂♂ 3 ♀♀ vi.23–vii.6.39 (H.H.).

This may be a mixed series but I cannot bring myself to splitting it between two names. Hoffmann does not include the race. I suspect that his *ulrica* is really *callina*.

274. **Phyciodes liriope guatemalena** Bates.

G. & S., **1**: 198, pl. 21, f. 23 (as *fragilis*).

R. (5), p. 435, pl. 89b (as *guatemala*).

Ha., p. 67.

H., p. 676.

So. of El Mante, San Luis Potosi, 1 ♂ iv.29.41 (R.P.).

El Sol, Tamazunchale, San Luis Potosi, 2 ♂♂ 10.31.41 (R. P.).

Hda. Potrero Viejo, Paraje Nuevo, Vera Cruz, 1500 ft., 1 ♂ 1 ♀ v.5.41 (R.P.).

Ojo de Agua, Vera Cruz, 1600 ft., 2 ♂♂ v.12.41 (R.P.).

Of these specimens only the El Mante specimen is as heavily marked as the figures given by Roeber (*l.c.*). Is *Phycoides mylitta mexicana* Hall (p. 44) synonymous with *guatemalena?*

275. **Phyciodes phaon phaon** Edwards.

G. & S., **2**: 677.

R., p. 436, pl. 89c.

Ha., p. 40.

H., p. 677.

Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 2 ♀♀ vi.16–17.40 (H.H.).

Monterrey, Nuevo Leon, 1800 ft., 3 ♀♀ iv.27.41 (R.P.).

60 mi. So. of Victoria, Tamaulipas, 1 ♀ vii.6.36 (H.D.T.).

Jacala, Hidalgo, 4500 ft., 1 ♂ vii.2.39 (H.H.).

The Jacala specimen and two of the Monterrey specimens are typical *phaon,* the others are f. *æstiva* Edwards. The known range is extended by the Jacala specimen.

276. **Phyciodes picta pallescens** Felder.

G. & S., **1**: 195, **2**: 678, pl. 21, ff. 18, 19.

R., p. 437, pl. 89e.

Ha., p. 50.

H., p. 676.

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♀ v.28.41 (R.P.).

El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).

The El Sol specimen establishes a new northern record for this form on the east coast of Mexico, extending the range given by

Hoffmann. Hoffmann lists *pallescens* (#276) as a distinct species, separate from *picta* (#281).

277. **Phyciodes tharos** Drury.
G. & S., **1**: 193, **2**: 436.
R., p. 436, pl. 89f.
Ha., p. 35.
H., p. 676.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 1 ♂ 2 ♀♀ vi.17–18.40. (H.H.).
Galeana, Nuevo Leon, 6500 ft., 1 ♂ viii.2.39 (H.H.).
El Sol Tamazunchale, San Luis Potosi, 1 ♂ 1 ♀ v.28 & iv.31.41 (R.P.).
None of these is f. *marcia* Edwards.

280. **Phyciodes vesta vesta** Edwards.
G. & S., **1**: 195, **2**: 678.
R., p. 436, pl. 89c.
Ha., p. 50.
H., p. 677.
Sabinas Hidalgo, Nuevo Leon, 960 ft., 3 ♂♂ 1 ♀ vi.15.39 (H.H.).
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 1 ♂ vi.18.40 (H.H.).
Hda. Sta. Engracia, Nuevo Leon, 1 ♂ vii.25.39 (H.H.).
nr. Villagran, Tamaulipas, 2 ♀♀ iv.28.41 (R.P.).
60 mi. So. of Victoria, Tamaulipas, 1 ♀ vii.6.36 (H.D.T.).
El Mante, San Luis Potosi, 1 ♂ iv.29.41 (R.P.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ 1 ♀ v.28.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ vii.22.39; 1 ♂ vi.27.40 (H.H.).
El Pujal, San Luis Potosi, 100 ft., 1 ♀ vii.21.39 (H.H.).

The San Luis Potosi specimens tend toward f. *boucardi* G. & S. The Nuevo Leon specimens are almost typical *vesta*.

282. **Phyciodes texana texana** Edwards.
G. & S., **1**: 200.
R., p. 442, pl. 90c.
Ha., p. 96.

H., p. 677 (as *Athanassa*).

Sabinas Hidalgo, Nuevo Leon, 690 ft., 1 ♂ vi.15.39 (H.H.).

Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 1000 ft., 1 ♂ vi.14.40 (H.H.).

Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 5 ♂♂ 2 ♀♀ vi.16–18.40 (H.H.).

Monterrey, Nuevo Leon, 1600 ft., 2 ♀♀ iv.27.41 (R.P.).

Galeana, Nuevo Leon, 6500 ft., 1 ♀ vii.30.39 (H.H.); 1 ♂ iv.29.41 (R.P.).

nr. Villagran, Tamaulipas, 1160 ft., 1 ♂ 1 ♀ iv.28.41 (R.P.).

60 mi. So. of Victoria, Tamaulipas, 1 ♀ vii.6.36 (H.D.T.).

Jacala, Hidalgo, 4500 ft., 5 ♂♂ 1 ♀ vi.23–vii.2.39 (H.H.).

This is the only member of this particular section of the *Phyciodes* that is easily recognized. The broad orange-brown area at the base of the forewing beneath is the characteristic which at once identifies it.

285. **Phyciodes ptolyca f. ptolyca Bates.**

G. & S., 1: 201 (in part), pl. 21, ff. 32, 33.

Ha., p. 91.

H., p. 677.

Galeana, Nuevo Leon, 6500 ft., 9 ♂♂ 1 ♀ iv.29.41 (R.P.).

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♂♂ 3 ♀♀ v. 29.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♂ vii.22.39; 1 ♂ vi.26.40 (H.H.).

Hda. Potrero Viejo, Paraje Nuevo, Vera Cruz, 1500 ft., 1 ♂ v.5.41 (R.P.).

Ojo de Agua, Vera Cruz, 1600 ft., 2 ♂♂ v.12.41 (R.P.).

285A. **Phyciodes ptolyca f. amator Hall.**

Ha., p. 92.

60 mi. So. of Victoria, Tamaulipas, 1 ♂ vii.6.36 (H.D.T.).

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♀ iv.31.41; 1 ♂ v.28.41 (R.P.).

El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ 2 ♀♀ vi.26–27.40 (H.H.).

Hda. Potrero Viejo, Paraje Nuevo, Vera Cruz, 1500 ft., 1 ♂ 1 ♀ v.5.41 (R.P.).
Fortin, Vera Cruz, 1600 ft., 1 ♀ v.6.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 1 ♀ v.6.41 (R.P.).
El Capirie, Michoacan, 500 ft., 1 ♀ viii.3.40 (H.H.).
El Sabino, Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

Hall considers this the western race of *ptolyca*. I believe it is only a pale form. Roeber, in Seitz', confused this species, *ptolyca*, with a form of *drusilla*, *lelex*. In general *ptolyca* is smaller than either *ardys* or *drusilla alethes* with which it is easily confused. I know of no good character for separating this species, but in series there are several intangible differences.

285a. **Phyciodes cortez** Hall.?
Ha., p. 93.
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♀ v.12.41 (R.P.).

I believe that I have correctly placed this species. The type hails from Cuautla (4000 ft.) in S. W. Mexico. It may be a white form of *tulcis*. This species is not included by Hoffmann in his list.

287. **Phyciodes ardys** Hewitson.
G. & S., **1**: 204, **2**: 681, pl. 22, ff. 4, 5.
R., p. 442, pl. 90d.
Ha., p. 90.
H., p. 677.
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1 ♂ 1 ♀ vi.18.40 (H.H.).
Tuxpango, Vera Cruz, 1500 ft., 2 ♂♂ v.9.41 (R.P.).
Fortin, Vera Cruz, 1600 ft., 1 ♂ 1 ♀ v.4.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 3 ♂♂ 2 ♀♀ v.6.41 (R.P.). One pair *in copula*.
Cumbres, (Km. 295) Vera Cruz, 8000 ft., 1 ♀ v.7.41 (R.P.).
El Sabino, nr. Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

This species may be separated from the following by the band on the upperside of the hindwing which is broken into spots on *ardys*. The Michoacan record is an extension of the known range.

287A. **Phyciodes drusilla alethes** Bates.

G. & S., **1**: 201 (as *ptolyca* in part).

R., p. 443, 8c as *lelex* on pl. 90, f. d.

Ha., p. 88.

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♀ v.28.41 (R.P.).

El Sabino, Uruapan, Michoacan, 4 ♂♂ 2 ♀♀ vii.15–30.36 (H.D.T.).

This race of *drusilla* closely resembles *ptolyca*. It differs from that species in the following respects: the light markings on the upper side are duller; the submarginal markings on the upper side of the forewings are more frequently complete; the underside of the hindwing is less contrasty. Hall states (p. 92) that the most important character is "the enlargement of the submarginal spot at the anterior angle of hindwing above" on *ptolyca*. I find this to be true in about 80% of my specimens.

This species is not included by Hoffmann in his list. He may have confused it with *ptolyca*.

290. **Phyciodes atronia atronia** Bates.

G. & S., **1**: 202, 207, **2**: 681, pl. 22, ff. 19–23 (as *atronia, argentea, cassiopeia*).

R., p. 441, pl. 90a (as *obscurata* & *cassiopeia*) p. 443, pl. 88i (as *atronia* & *argentea*).

Ha., p. 108.

H., p. 677 (as *Athanassa*).

Ojo de Agua, Vera Cruz, 1600 ft., 3 ♂♂ v.12.41 (R.P.).

I have followed Hall (*l.c.*) in respect to this very variable species. My specimens are what Roeber (*l.c.*) called *cassiopeia*.

293. **Phyciodes myia myia** Hewitson.

G. & S., **1**: 188, **2**: 674.

R., p. 444, pl. 90e.

Ha., p. 136.

H., p. 678 (as *Eresia*).

Tuxpango, Vera Cruz, 1500 ft., 2 ♂♂ v.9.41 (R.P.).

Fortin, Vera Cruz, 1600 ft., 2 ♂♂ 1 ♀ v.4.41 (R.P.).

Ojo de Agua, Vera Cruz, 1600 ft., 7 ♂♂ 5 ♀♀ v.12.41 (R.P.).

El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).

These are all typical *myia*. Hall records a single specimen of the slightly different race *griseobasalis* Bates from Western Mexico, Sierra Madre de Tepec. My single female from Michoacan does not show any indication of being that race.

297. **Phyciodes eranites** Hewitson.

G. & S., **1**: 185, **2**: 673.
R., p. 446, pl. 92c & d (as *evanites*).
Ha., p. 164.
H., p. 678.
Fortin, Vera Cruz, 1600 ft., 1 ♂ v.4.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♀ v.12.41 (R.P.).

298. **Phyciodes phillyra** Hewitson.

G. & S., **1**: 184, **2**: 674.
R., p. 448, pl. 92c.
Ha., p. 167.
H., p. 678.
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♀ iv.31.41 (R.P.).
Tuxpango, Vera Cruz, 1500 ft., 1 ♂ 2 ♀♀ v.9.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 1 ♂ v.24.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 2 ♂♂ v.6.41 (R.P.).

The Tuxpango females are much larger and the coloring less intense than on the El Sol female. Not previously reported from San Luis Potosi.

299. **Chlosyne janais** Drury.

G. & S., **1**: 178, **2**: 671.
R., p. 451, pl. 91f.
H., p. 678.
Ojo de Agua, Sabinas Hidalgo, Nuevo Leon, 1000 ft., 1 ♂ vi.15.40 (H.H.).
Sabinas Hidalgo, Nuevo Leon, 960 ft., 1 ♀ vi.15.40 (H.H.).
Hda. Vista Hermosa, Nuevo Leon, 1500 ft., 1 ♀ vi.17.40 (H.H.).

Galeana, Nuevo Leon, 6500 ft., 6 ♂♂ iv.29.41 (R.P.).
Nr. Villagran, Tamaulipas, 1160 ft., 1 ♀ iv.28.41 (R.P.).
Arroyo del Meco, Tamaulipas, 1320 ft., 3 ♂♂ iv.28.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 1 ♂ 1 ♀ vi.24.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ v.28.41 (R.P.).
Ojo de Agua, Vera Cruz, 1600 ft., 2 ♂♂ 4 ♀♀ v.12.41 (R.P.).

300. **Chlosyne lacinia** Geyer.

The multitude of forms of this species are so hopelessly confused and the names proposed for them so numerous that I am unwilling to put names to any without much more material and study. Therefore I shall merely list the specimens under brief descriptions.

a) rufous markings on the upper side of both wings, those of the forewing forming a more or less continuous band as in G. & S. pl. 19, f. 8 & 10: the underside of the hindwings as in f. 7: underside of forewings as in f. 13 with added basal spots. This form I believe is best called *adjutrix* Scudder.

Sabinas Hidalgo, Nuevo Leon, 960 ft., 1 ♀ vi.15.39 (H.H.).
Monterrey, Nuevo Leon, 1800 ft., 3 ♂♂ 1 ♀ iv.27.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 1 ♂ vii.2.39 (H.H.).
El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♂♂ iv.31 & 3 ♀♀ v.28.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ vi.26–27.41 (H.H.).
El Sabino, Uruapan, Michoacan, 1 ♂ vii.15–30.36 (H.D.T.).

The Michoacan specimen is atypical to this extent: the basal spots are absent and the transverse bands are chestnut, narrow and ill-defined on the upper surface.

b) similar to *a*) but lacking the yellow marginal lunules on the underside of the hindwings.

Jacala, Hidalgo, 4500 ft., 1 ♀ vii.2.39 (H.H.).

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♀ iv.31.41 (R.P.).

c) similar to *a*) on the upper side but lacking the brown markings on the forewing. Underside of hindwing with orange brown spots outside of yellowish buff transverse band—see Seitz' pl. 91d—*mediatrix.*

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 1 ♂ v.28.41 (R.P.).
Fortin, Vera Cruz, 1600 ft., 2 ♂♂ v.4.41 (R.P.).
Orizaba, Vera Cruz, 2000 ft., 1 ♂ v.6.41 (R.P.).
Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.).

d) similar to *c*) but lacking the series of orange brown spots on the underside of the hindwings.

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 4 ♂♂ 2 ♀♀ v.28–29.41 (R.P.).
Tuxpango, Vera Cruz, 1500 ft., 1 ♂ v.9.41 (R.P.).
Fortin, Vera Cruz, 1600 ft., 1 ♂ v.4.41 (R.P.).
Orizaba, Vera Cruz, 1600 ft., 1 ♂ v.6.41 (R.P.).

e) similar to *c*) but brown area on hindwing above diffuse and reduced.

El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).

f) similar to *d*) and varying from that as *e*) does from *c*).

El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).

g) similar to *c*) on the upper side but brown band reduced to a series of small spots; beneath lacking the yellow transverse band on the hindwing.

El Sol, Tamazunchale, San Luis Potosi, 400 ft., 2 ♀♀ v.28.41 (R.P.).
Fortin, Vera Cruz, 1600 ft., 1 ♀ v.4.41 (R.P.).

h) upper surface lacks all trace of brown: underside with yellow submarginal lunules, transverse band and basal spots on the hindwing (*quehtala* Reakirt?).

Iguala, Guerrero, 1 ♂ v.27.41 (R.P.).
El Sabino, Uruapan, Michoacan, 1 ♂ 1 ♀ vii.15–30.36 (H.D.T.).

i) similar to *h*) but lacking the yellow on the underside of the hindwings (*adelina* Stdgr.?).

Rio Balsas, Guerrero, 2400 ft., 2 ♂♂ v.26.41 (R.P.).
Apatzingan, Michoacan, 1050 ft., 1 ♂ 1 ♀ *in copula* viii.2.40 (H.H.).
El Capirie, Michoacan, 500 ft., 1 ♂ viii.3.40 (H.H.).

j) white spotted forewing, hindwing with a light area extended at least half way from the base to the outer margin which it parallels. The area is not solidly colored but varies from buff to orange brown. Under side like the upper side (*lacinia* Hübner?).

Galeana, Nuevo Leon, 6500 ft., 1 ♂ iv.29.41 (R.P.).
60 mi. So. of Victoria, Tamaulipas, 1 ♂ 1 ♀ vii.6.36 (H.D.T.).
El Bañito, Valles, San Luis Potosi, 200 ft., 2 ♂♂ 1 ♀ vi.26–28.40 (H.H.).

303. **Chlosyne hippodrome** Geyer.

(figured as *hyperia* by Seitz' pl. 91f.).
H., p. 679.
Ojo de Agua, Vera Cruz, 1600 ft., 6 ♂♂ 5 ♀♀ v.12.41 (R.P.).
Chichen Itza, Yucatan, 2 ♂♂ viii.30.36 (H.D.T.).
Acahuato, Michoacan, 1 ♂ viii.2.40 (H.H.).
El Sabino, Uruapan, Michoacan, 1 ♀ vii.15–30.36 (H.D.T.).

There is no difference between east and west coast specimens. Hoffmann does not record this species from Michoacan.

305. **Chlosyne erodyle** Bates.

G. & S., **1**: 180, **2**: 672, pl. 20, ff. 3, 4.
R., p. 452, pl. 91h.
H., p. 679.
Rio Blanco, Vera Cruz, 2200 ft., 1 ♂ v.10.41 (R.P.).

307. **Chlosyne dryope** Godman & Salvin.
G. & S., **2**: 672, pl. 108, ff. 3, 4.
H., p. 679.
Iguala, Guerrero, 1 ♂ v.22.41 (R.P.).
Rio Balsas, Guerrero, 2400 ft., 1 ♀ v.26.41 (R.P.).

Hoffmann records this species only from Jalisco.

311. **Chlosyne endeis** Godman & Salvin.
G. & S., **2**: 673, pl. 108, ff. 5, 6.
H., p. 679.
Jacala, Hidalgo, 4500 ft., 3 ♂♂ 1 ♀ vi.23–vii.6.39 (H.H.).

The transverse discal band on a fresh specimen is fulvous. On the other three which are flown it appears white. This seems to be due to a great extent to the loss of the fulvous scales which seem to be very loosely attached.

This is the first record of this species on the eastern slope of Mexico.

314. **Microtia elva** Bates.
G. & S., **1**: 120, **2**: 682, pl. 20, f. 23.
R., p. 453, pl. 88h.
H., p. 669–70.
Sabinas Hidalgo, Nuevo Leon, 960 ft., 1 ♂ vi.18.39 (H.H.).
Hda. Vista Hermosa, Villa Santiago, Nuevo Leon, 1500 ft., 2 ♂♂ vi.17–20.40 (H.H.).
nr. Villagran, Tamaulipas, 1160 ft., 1 ♂ 1 ♀ iv.28.41 (R.P.).
Arroyo del Meco, Tamaulipas, 1320 ft., 3 ♂♂ iv.28.41 (R.P.).
Jacala, Hidalgo, 4500 ft., 6 ♂♂ 5 ♀♀ vi.23–29.39 (H.H.).
So. of El Mante, San Luis Potosi, 1 ♀ iv.29.41 (R.P.).
El Bañito, Valles, San Luis Potosi, 200 ft., 1 ♀ vii.22.39; 2 ♂♂ 1 ♀ vi.26–27.40 (H.H.); 2 ♂♂ 1 ♀ iv.30.41 (R.P.).
Acapulco, Guerrero, 100 ft., 1 ♀ v.26.41 (R.P.).
Iguala, Guerrero, 1 ♂ 1 ♀ v.22.41 (R.P.).
Acahuato, Michoacan, 3000 ft., 1 ♀ viii.2.40 (H.H.).

Apatzingan, Michoacan, 1050 ft., 1 ♀ viii.2.40 (H.H.).
El Capirie, Michoacan, 500 ft., 1 ♂ viii.3.40 (H.H.).

One of the males from El Bañito, iv.30.41, and the Sabinas Hidalgo male may be termed f. *horni* Rebel. As a matter of fact these two specimens are closer to f. *draudti* Röber which I consider to be merely an intermediate form lying between *elva* and f. *horni*.

The west coast females tend to be generally larger than those from the east coast, 18 mm. vs. 16 mm. baso-apical radius of the forewing. The males are about the same size from both coasts.

315. **Morpheis ehrenbergii** Huebner.
G. & S., **1**: 211, **2**: 682.
R., p. 454, pl. 93a.
H., p. 670.
Jacala, Hidalgo, 4500 ft., 3 ♂♂ 10 ♀♀ vi.23–vii.24.39 (H.H.).
Tancitaro, Michoacan, 6586 ft., 2 ♂♂ 1 ♀ vii.20–30.40 (H.H.).

Hoffmann carefully listed the States from which this local species has been reported. Neither of the two here noted occurs in his list.

BIBLIOGRAPHY

1. GODMAN & SALVIN, Biologia Centrali-americana, 1: 143–211, 1881–1882; 2: 667–682, 1901.
2. SEITZ, Macrolepidoptera of the World, 5: 357–433, 1911–1913.
3. HOFFMANN, Anales del Instituto de Biologia, 11: 639–738, 1940.
4. HALL, Supplement to Bull. Hill Museum, 2–4: 206 pp., 1928–1930.
5. ROEBER, in Seitz' Macrolepidoptera of the World, 5: 434–454, 1913–1914.

A REVISION OF THE NORTH AMERICAN GENUS EREMOMYIOIDES MALLOCH (DIPTERA, MUSCIDÆ)

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The native genus *Eremomyioides* was established by Malloch[1] for the reception of three species, *Pegomyia setosa* Stein, *Eremomyia cylindrica* Stein and a new form *Eremomyioides parkeri*. The second species, *cylindrica*, was chosen as the genotype. Later Malloch[2, 3] recorded two new species belonging to the genus, *E. fuscipes* and *E. similis*, and published a key to the known forms. There is now before me a sixth species which has not been recognized, and also the male of *parkeri*.

The distinguishing characters of *Eremomyioides* are well marked and distinctive. All the species possess setulæ on all pleural and sternal sclerites of thorax, including propleura, pteropleura, hypopleura, prosternum and metasternum. In addition, all species lack cruciate setæ on interfrontalia; they possess a bristle near middle of anteroventral surface of middle femora and middle tibiæ, and bear numerous stout short setulæ on vibrissal angle. In the male the structure of hypopygium and copulatory appendages is typical of all species, being more robust in *parkeri* and *setosa*. The prebasal sclerite of hypopygium (tegrum 6 of Crampton)[4] has numerous bristles. The females have two or more of the fore tarsal segments broadened. The genus in my opinion finds its closest relationships in the *major*-group of the genus *Pegomyia*,[5] and in *Eremomyia* as delimited by Ringdahl.[6]

[1] Malloch, J. R. 1918. Notes and descriptions of some anthomyid genera. Proc. Biol. Soc. Wash., 31: 67–68.

[2] Malloch, J. R. 1920. Descriptions of new North American Anthomyiidæ (Diptera). Trans. Amer. Ent. Soc., 46: 182–183.

[3] Malloch, J. R. 1921. Synopses of some North American Anthomyiinæ (Diptera). Can. Ent., 53: 76–77.

[4] Crampton, G. C. 1941. The terminal abdominal structures of male *Diptera*. Psyche, 48: 94, fig. 20.

[5] Huckett, H. C. 1941. A revision of the North American species belong-

The adults of the species are commonly collected in the Spring in the neighborhood of woodland terrain. From available information it would seem that the species *cylindrica* is widely distributed across the continent from Alaska to Quebec. A single specimen of *similis* has been taken at Boulder, Colorado, and of *fuscipes* in the foothills of the Appalachian Mountains in Georgia.

Genus *Eremomyioides* Malloch

Eremomyioides Malloch, 1918, Proc. Biol. Soc. Wash., 31: 67. Curran, 1934, Fam. Gen. N. A. Dipt., p. 391. Séguy, 1937, Gen. Insect., Fasc. 205, p. 122.

Eremomyoides Malloch, 1921, Can. Ent., 53: 76. Huckett, 1924, N. Y. (Cornell) Agr. Exp. Sta., Mem. 77 (1923), p. 12.

Genotype: *Eremomyia cylindrica* Stein.

KEYS TO SPECIES

Males

1. Eyes separated at narrowest by a distance greater than twice that between posterior ocelli inclusive; parafrontals bristled to vertex, vertical and paraorbital bristles robust; hypopygium prominently protruded caudad, anal sclerite (tergum 9) longer than length of process on fifth abdominal sternum 2

   Eyes separated at narrowest by a distance not greater than twice that between posterior ocelli inclusive; parafrontals bare caudad, verticals slender, paraorbital bristles lacking; hypopygium inconspicuous, not protruding caudad, anal sclerite not longer than process of fifth abdominal sternum 3

2. Hind femur with long, stiff bristles on proximal region of antero- and posteroventral surfaces which are directed apicad, stouter than those on distal half of anteroventral surface . .. *parkeri* Mall.

   Hind femur with bristles on proximal region of antero- and posteroventral surfaces directed ventrad and not stouter than those on distal half of anteroventral surface .. .. *setosa* (Stein)

3. Eyes separated by a distance not greater than that between posterior ocelli inclusive; bristles of middle pair of presutural acrosticals separated by a distance greater than that between eyes; hind tibia largely reddish yellow, apical anterior bristle weak . . . *cylindrica* (Stein)

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ing to the genus Pegomyia. (Diptera: Muscidæ) Mem. Amer. Ent. Soc., No. 10, p. 14.

[6] Ringdahl, O. 1933. Översikt av i Sverige funna Hylemyia-arter. Ent. Tidskr., Årg. 54, häft 1, p. 30.

Eyes separated by a distance greater than that between posterior ocelli inclusive; bristles of middle pair of presutural acrosticals separated by a distance less than that between eyes 4

4. Hind tibia with 3 or 4 anterodorsal and 3 or 4 posterodorsal bristles. *conscripta* n. sp.

Hind tibia with fewer bristles on one or other of dorsal surfaces, usually with 2 anterodorsal and 2 posterodorsal bristles 5

5. Costal setulæ scarcely as long as width of costa, serially conforming to costal hairs; thorax with 3 pairs of presutural acrostical bristles; inner margin of second antennal segment extending obliquely across base of third segment and angularly projected on the lower half *fuscipes* Mall.

Costal setulæ proximad of costal thorn slightly longer than width of costa, more widely spaced apart than costal hairs; thorax with two pairs of presutural acrosticals; inner margin of second antennal segment extending transversely at right angles across base of third segment, and not forming an angular prominence on lower half *similis* Mall.

Females

1. Fifth abdominal tergum obtusely rounded and swollen at apex, curved ventrad, armed with a loose tuftlike series of bristles; opening to ovipositor situated on ventral surface of abdomen and basad of apex. *parkeri* Mall.

Fifth abdominal tergum not rounded nor swollen on caudal region, armed with a transverse series of marginal bristles; opening to ovipositor situated at apex of abdomen . 2

2. Mid and hind femora reddish yellow . *cylindrica* (Stein)

Mid and hind femora largely blackish . 3

3. Hind tibia with 3 or 4 anterodorsal and 3 or 4 posterodorsal bristles; hind tibia largely reddish yellow . . . 4

Hind tibia with fewer bristles on one or other of dorsal surfaces, usually with 2 anterodorsal and 2 posterodorsal bristles; hind tibia largely blackish tinged 5

4. Costal setulæ robust and in a prominent series distad and proximad of costal thorn, longest setulæ about equal in length to humeral cross vein and most of the setulæ nearly twice as long as width of costa. *setosa* (Stein)

Costal setulæ weak, inconspicuous, scarcely longer than width of costa. *conscripta* n. sp.

5. Inner margin of second antennal segment extending obliquely across base of third segment and angularly projected on lower half; costal setulæ scarcely longer than width of costa . . . . *fuscipes* Mall.

Inner margin of second antennal segment extending transversely at right angles across base of third segment, and not forming an angular prominence on lower half; costal setulæ longer than width of costa. *similis* Mall.

Eremomyioides parkeri Malloch

Eremomyioides parkeri Malloch, 1918, Proc. Biol. Soc. Wash., 31: 67. Séguy, 1937, Gen. Insect., Fasc. 205, p. 122.

Eremomyoides parkeri Malloch, 1921, Can. Ent., 53: 76 Strickland, 1938, Can. Jour. Res., Sect. D, 16: 209.

The male resembles *setosa,* having eyes widely separated and frons bristled to vertex. It may be distinguished from the latter species by the bristles on proximal half of antero- and posteroventral surfaces of hind femur, which are coarser and stouter and are directed apicad. The male has a stout apical bristle on anterior surface of hind tibia, but the bristle at middle of anterior surface is very weak in the specimens before me, as is also the lower posthumeral bristle. The fore femora lack the usual series of longish setulæ on median plane of anterior surface.

Alberta: ♂, Medicine Hat, April 2, 1926 (F. S. Carr), allotype [C.N.C.]. ♀, Elk Island, May 16, 1937 (E. H. Strickland) [Univ. Alberta]. ♀, Calgary, May 1, 1939 (W. S. McLeod).

Saskatchewan: ♂, Oxbow, May 11, 1907 (Fredk. Knab) [U.S.N.M.]. ♀, Ogema, June 16, 1916 (N. Criddle) [C.N.C.].

Eremomyioides setosa (Stein)

Pegomyia setosa Stein, 1898, Berl. Ent. Zeitschr., (1897) 42, heft 3 & 4, p. 247. Aldrich, 1905, Misc. Coll. Smithsn. Inst., 46: 558.

Eremomyioides setosa Malloch, 1918, Proc. Biol. Soc. Wash., 31: 67.

Eremomyia setosa Stein, 1919, Arch. f. Naturgesch., (1917) 83, Abt. A, heft 1, p. 153. Séguy, 1937, Gen. Insect., Fasc. 205, p. 122.

Eremomyoides setosa Malloch, 1921, Can. Ent., 53: 76, 77.

In both *setosa* and *parkeri* the hypopygium is much larger than in other species belonging to the genus. The female of *setosa* has all femora largely blackish, costal setulæ robust, and hind tibiæ armed with 3 or 4 anterodorsal and 3 or 4 posterodorsal bristles.

Alaska: 2 ♂, Katmai, June, 1917 (J. S. Hine).

Idaho: ♀, Moscow, cotype [Chicago Nat. Hist. Mus.].* ♀, Juliaetta, May 11, 1902 [N.S.N.M.].

* Formerly the Field Museum of Natural History.

Oregon: ♂, ♀, Meacham, May 8, 1927, 3680 ft. alt. (H. A. Scullen) [Ore. State Coll.].

Washington: ♀, Davenport, April 4, 1935 (J. Wilcox).

Eremomyioides cylindrica (Stein)

Eremomyia cylindrica Stein, 1898, Berl. Ent. Zeitschr., (1897) 42, heft 3 & 4, p. 226. Aldrich, 1905, Misc. Coll. Smithsn. Inst., 46: 554. Smith, 1910, Ann. Rept. N. J. State Museum 1909, p. 791. Johnson, 1913, Bull. Amer. Mus. Nat. Hist., 32, Art. 3, p. 78. Stein, 1919, Arch. f. Naturgesch., (1917) 83, Abt. A, heft 1, p. 153. Stein, 1920, Arch. f. Naturgesch., (1918) 84, Abt. A, heft 9, p. 73, 74.

Eremomyioides cylindrica Malloch, 1918, Proc. Biol. Soc. Wash., 31: 67. Séguy, 1937, Gen. Insect., Fasc. 205, p. 122.

Eremomyoides cylindrica Malloch, 1921, Can. Ent., 53: 76. Huckett, 1924, N. Y. (Cornell) Agr. Exp. Sta., Mem. 77 (1923), p. 12. Johnson, 1925, Occas. Pap. Boston Soc. Nat. Hist., 7: 233. Johnson, 1925, Proc. Boston Soc. Nat. Hist., 38: 93. Leonard, 1928, N. Y. (Cornell) Agr. Exp. Sta., Mem. 101 (1926), p. 837. Strickland, 1938, Can. Jour. Res., Sect. D, 16: 209.

The male of *cylindrica* may invariably be distinguished by the combination of characters given in the key. In this sex the second antennal segment and tibiæ range in color from yellowish or reddish to blackish. In the female the middle and hind femora and all tibiæ are reddish yellow, and the costal setulæ, like those of the male, are short and arranged in an inconspicuous series.

Alberta: ♀, Wabamun, April 24, 1939, ♂, Edmonton, May 1, 1937, 3 ♀, Fawcett, May 8, 1934 (E. H. Strickland).

Massachusetts: ♂, New Bedford, April 29, 1896 (Hough), cotype [Chicago Nat. Hist. Mus.]. ♀, Wellesley, May 15, 1919 (J. D. Tothill).

Michigan: 2 ♀, Ann Arbor, May 18, 1923 (J. S. Hine) [Ohio State Mus.].

Minnesota: ♀, St. Anthony Park (Lugger), cotype [Chicago Nat. Hist. Mus.].

New York: ♂, Ithaca, May 15, 1914 [C.U.]. ♂, Patterson, April 24, 1935, ♀, Brewster, April 30, 1936 (H. Dietrich) [C.U.]. ♂, ♀, Riverhead, Long Island, May 8, 1927.

Ohio: ♂, West Liberty, April 12, 1931 (R. B. Gordon). ♀, Neotoma, Hocking County, March 28, 1932 (E. S. Thomas) [Ohio State Mus.].

Ontario: ♂, Strathroy, April 22, 1927 (H. F. Hudson). ♀, Low Bush, Lake Abitibi, June 8, 1925 (N. K. Bigelow) [C.N.C.]. ♀, Jordan, June 18, 1926 (G. S. Walley). ♀, Fenelm Falls, May 27, 1927 (F. P. Ide).

Pennsylvania: ♀, Broomall, May 6, 1934 [Brigham Young Univ.].

Quebec: ♀, Aylmer, May 14, 1925 (G. S. Walley). ♀, Hull, May 12, 1925 (C. H. Curran) [C.N.C.].

Eremomyioides conscripta new species

MALE, blackish, resembling *fuscipes* in habitus, second antennal segment reddish along distal margin, parafacial pruinescence brownish, mesonotum subshining, with a dorsocentral stripe and trace of sublaterals caudad of transverse suture, abdomen grayish white pruinescent, dorsocentral vitta gradually becoming broader caudad, legs blackish, hind tibiæ with trace of reddish tinge, calyptræ whitish, halteres purplish tinged.

Eyes separated by about width of third antennal segment, inner margin of second antennal segment squarely transverse across base of third segment, two pairs of presutural acrostical bristles, apical bristles of processes of fifth abdominal sternum fine and slender, costal setulæ not longer than width of costa, inconspicuous; fore tibia with 2 posteroventral bristles, mid tibia with 1 anteroventral, 1 anterior, 1 anterodorsal, 1 posterodorsal, 3 posterior bristles, hind tibia with 2 or 3 anteroventral, 4 anterodorsal and 4 posterodorsal bristles, 1 or 2 median anterior bristles, apical anterior bristle well developed. Length 8 mm.

FEMALE, as male, second antennal segment more broadly reddish, abdominal stripe less distinct, cross veins slightly infuscated, hind tibiæ largely reddish, costal setulæ fine, slightly longer than width of costa, tibiæ bristled as in male, fore tarsal segments 2, 3, 4 and 5 narrowly broadened, when compared to those of mid tarsus, fourth fore tarsal segment fully twice as long as wide. Length 7.5 mm.

Holotype and allotype: ♂, ♀, Copper Mountain, British Columbia, April 8, 1928, *Betula occidentalis* sap (G. Stace Smith) [C.N.C.].

The species *conscripta* comes closest to *fuscipes* and *similis*, from both of which it may usually be distinguished by the greater number of bristles on hind tibia. In *conscripta* the costal setulæ are weak, the inner margin of second antennal segment does not

proceed obliquely across base of third segment, and there are only two pairs of presutural acrostical bristles. The female of *conscripta* has paler hind tibiæ than in *fuscipes* and *similis*, and the costal setulæ are much weaker than those of *setosa*.

Eremomyioides fuscipes Malloch

Eremomyioides fuscipes Malloch, 1920, Trans. Amer. Ent. Soc., 46: 182. Frison, 1927, Bull. Ill. Nat. Hist. Surv., 16, Art. 4, p. 198. Séguy, 1937, Gen. Insect., Fasc. 205, p. 122.

Eremomyoides fuscipes Malloch, 1921, Can. Ent., 53: 76. Huckett, 1924, N. Y. (Cornell) Agr. Exp. Sta., Mem. 77 (1923), p. 12. Leonard, 1928, N. Y. (Cornell) Agr. Exp. Sta., Mem. 101 (1926), p. 837.

The speces *fuscipes* and *similis* are closely allied, both having the tibiæ largely blackish in both sexes. However the hind tibiæ, and to a less extent the middle tibiæ, do exhibit a more or less obscure reddish tinge in certain specimens. In *fuscipes* the hind tibia may, or as is more general, may not have a bristle at middle of anterior surface. The costal setulæ in both sexes are weak, and the inner distal margin of second antennal segment is oblique in its course across base of third segment, thereby forming an angular prominence or outline on lower half. In *similis* the costal setulæ are longer than width of costa, and inner margin of second antennal segment is more nearly rectangular across base of third segment.

Alberta: ♂, Edmonton, May 13, 1937 (E. H. Strickland).

Connecticut: ♂, South Meriden, March 15, 1915 (H. L. Johnson).

Georgia: ♀, Clayton, April 15–22, 1940 (H. C. Huckett).

Illinois: ♂, Urbana, March 18, 1918 (Frison and Malloch), paratype [Ill. Nat. Hist. Surv.].

New York: ♂, Ithaca, March 25, 1917 (R. C. Shannon). ♂, Fall Creek, Ithaca, April 24, 1922 (L. S. West). ♂, Cooper Cemetery, Staten Island, March 17, 1918.

Ohio: ♀, Columbus, March 27, 1907.

Pennsylvania: 2 ♂, Hawley, April 20, 1936 (H. Dietrich).

South Carolina: ♀, Clemson College, February 22, 1936 (D. Dunavan).

Eremomyioides similis Malloch

Eremomyioides similis Malloch, 1920, Trans. Amer. Ent. Soc., 46: 183. Frison, 1927, Bull. Ill. Nat. Hist. Surv., 16, Art. 4, p. 198. Séguy, 1937, Gen. Insect., Fasc. 205, p. 122.

Eremomyoides similis Malloch, 1921, Can. Ent., 53: 76, 77.

The distinguishing characters and relationships of this species have already been discussed in notes concerning *conscripta* and *fuscipes*. The species has in error been recorded by me as occurring in New York from specimens which I now regard as belonging to *fuscipes*.

Alberta: ♂, Edmonton, May 13, 1937 (E. H. Strickland).

Colorado: ♂, Campus, University of Colorado (Cockerell) [N.S.N.M.].

Illinois: ♀, Tuscola, March 29, 1918, paratype [C.N.C.]. ♂, Urbana, Brownfield Woods, April 23, 1919, paratype [Ill. Nat. His. Surv.].

South Dakota: ♂, Brookings, April 29, 1919 [Ohio State Mus.].

Wisconsin: ♂, Dane County, April 10, 1900 (F. M. Snyder).

RECORDS AND DESCRIPTIONS OF NEOTROPICAL CRANE-FLIES (TIPULIDÆ, DIPTERA), XVIII

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The preceding part under this title was published in March, 1944 (JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY, 52: 45–57). The species discussed at this time are chiefly from Costa Rica, Panama and Bolivia, derived from sources that are mentioned under the individual species. The types of the novelties are preserved in my private collection of these flies, except where stated to the contrary.

Genus *Tanypremna* Osten Sacken

Tanypremna (Tanypremna) saltatrix new species.

Size large (length, male, over 30 mm.); mesonotal præscutum with disk almost covered by four reddish brown stripes, the usual interspaces darkened and impressed; thoracic pleura yellow, with a narrow interrupted transverse girdle extending from the præscutum to the sternopleurite; tibiæ with a conspicuous white ring about its own length before tip; basal four tarsal segments black with broad white tips; wings subhyaline, the veins seamed with pale brown; cell Sc_2 small and narrow, tending to become closed at margin; male hypopygium with the dististyle provided with 13 or 14 small black spines arranged in a single row.

MALE.—Length about 33–34 mm.; wing 18.5–19 mm.; abdomen alone about 28–29 mm.

Frontal prolongation of head yellow; palpi greenish yellow. Antennæ with scape and pedicel yellow; flagellar segments pale brown, the outer ones darker; segments cylindrical, the verticils longer than the segments. Head chiefly yellow sericeous, darker behind.

Pronotum conspicuously blackened above, paling to yellow on sides. Mesonotal præscutum with the disk almost covered by four reddish brown stripes that are very narrowly separated by capillary black lines, the ones delimiting the usual interspaces impressed; a dark transverse line on præscutum extending from cephalic end of lateral stripe to the lateral margin, interrupting the broad yellow lateral and humeral border; scutal lobes reddish brown, divided into two unequal areas by narrowly blackened borders and lines; scutellum testaceous brown; mediotergite dark brown, the central portion behind somewhat paler; lateral border of mediotergite and dorsal portion of katapleurotergite pale, the remainder of pleurotergite dark brown. Pleura yellowish white, with a more or less interrupted transverse girdle extending from the

lateral præscutal border, as above described, crossing the dorsopleural membrane, on the anepisternum and sternopleurite being broken into linear spots. Halteres with stem obscure yellow, knob dark brown. Legs with coxæ yellow, outer face of each with a brownish black stripe, broadest on posterior coxæ; trochanters yellow; fore and middle legs with femora yellow basally, passing into dark brown, most intense at outer ends but preceded by a very vague paler subterminal ring; tibiæ black, with a relatively narrow but conspicuous white ring about its own length from tip; fore tibiæ with extreme bases vaguely whitened; basitarsi black with the tips white, on fore legs involving about the distal fourth, on the middle legs a little less; succeeding three tarsal segments black with their tips broadly white; terminal segment uniformly brownish black; posterior legs similar but with the white rings on tibiæ and basitarsi even wider, the latter including almost the outer third of segment. Wings subhyaline, the small stigma dark brown; cell *Sc* and seams along most of veins paler brown, these seams wider and more diffuse on the posterior and caudal veins. Venation: Cell Sc_2 very small and narrow, in holotype closed at margin by approximation of veins Sc_2 and R_{1+2}; *Rs* straight and oblique, in alignment with R_{4+5}; cell *1st* M_2 about one-half wider than long, narrower at outer end; cell M_1 about twice its petiole; *m–cu* subequal to basal section of M_{3+4}; cell *2nd A* relatively wide.

Abdomen elongate; tergites brown, on more proximal segments narrowly ringed with obscure yellow; outer segments more uniformly darkened; pleural membrane dark; sternites yellow, their posterior borders darkened; eighth and ninth segments dark, the tips of basitarsi pale. Male hypopygium with tergal lobes broadly and obtusely rounded. Basistyle elongate; mesal face at near two-thirds the length with a conspcuious lobe that is provided with about a dozen long pale setæ. Dististyle provided with about 13 or 14 short blackened spines arranged in a single row, with more than half placed on the distal third of row; inner branch of style obtuse, provided with abundant short setæ.

Habitat.—Costa Rica.

Holotype, ♂, Rivas, altitude 2,875 feet, January 1939 (Dean Rounds). Paratype, ♂, Pedregoso, altitude 2,075 feet, January 1939 (Dean Rounds).

The nearest relatives of the present fly are the Brazilian *Tanypremna* (*Tanypremna*) *longissima* (Enderlein) and *T*. (*T*.) *manicata* Osten Sacken, both of which differ conspicuously in the relative proportions and in details of coloration of body and legs. These species have been keyed and described in an earlier paper by the writer (JOUR. N. Y. ENT. SOC., 22: 205–218, 1914).

Tanypremna (Tanypremna) clotho new species.

Mesonotum very high and gibbous, dark brown, the sides broadly and abruptly yellow; pronotum narrowly darkened medially; pleura pale yellow;

mesosternum with a conspicuous black spot; legs black, tibiæ with a broad white subterminal ring; tarsal segments one and two black basally, their tips broadly white; segments three and four white; wings pale brown, the costal region slightly darker; stigma and a cloud over cord darker brown; R_{2+3} sinuously bent; cell *1st* M_2 large, square at base, narrowed outwardly; petiole of cell M_1 about twice *m*; cell *2nd A* unusually narrow; abdomen elongate, tergites chiefly dark brown, restrictedly patterned with obscure yellow; cerci black.

FEMALE.—Length about 41 mm.; wing 20 mm.; abdomen alone 36 mm.

Frontal prolongation of head short, almost white; nasus distinct; palpi pale, tinged with greenish, the proximal end of the terminal segment darker. Antennæ with scape and pedicel pale, the basal flagellar segments greenish, outer segments dark brown; flagellar segments elongate, with conspicuous verticils. Front and anterior vertex silvery white; occiput and the transverse adjoining portions of vertex almost black, the remainder of vertex paling to brown; genæ obscure yellow.

Pronotum conspicuously dark brown medially, the sides abruptly yellow. Mesonotal præscutum almost uniform dark brown, the area strongly narrowed in front to leave a very broad humeral and lateral area on either side; the four præscutal stripes differentiated by impressed lines at the interspaces; scutal lobes similarly dark brown, the median region sparsely yellow pollinose; scutellum testaceous brown, the parascutella darker; mediotergite chiefly dark brown, the lateral and posterior borders pale to form a U-shaped border; median region at base more reddened; pleurotergite dark brown, the posterior angle above the halteres abruptly yellow. Mesonotal præscutum high and gibbous. Pleura uniformly pale yellow; sternum pale except for a very evident oval black area on mesosternum. Halteres relatively long, stem brown, yellow at base, knob slightly brightened. Legs with coxæ pale greenish yellow, the posterior pair with a brown spot on caudal aspect; trochanters greenish yellow, the middle pair blackened on posterior face; fore and hind femora brown, paler basally, darker brown at and before tips, middle femora uniform brownish black; tibiæ brownish black, with a broad white subterminal ring, narrowest on fore legs where it is only a little more than twice the blackened apex, broad on middle and posterior tibiæ, especially the latter, where the white is approximately four times the blackened apex; basitarsi black on proximal portion, the tip broadly white, involving about the distal two-thirds of segment, slightly less extensive on middle legs; tarsal segment two black at base, the tip white, broadest on fore legs where about the distal three-fourths to four-fifths of segment is included, narrower on middle and hind legs where more than half the segment is whitened, more extensively so on middle legs; tarsal segments three and four greenish white; terminal segment pale brown; claws (female) simple. Wings with a pale brownish tinge, the broad costal cell slightly darker, cell *Sc* even darker brown; stigma small, ill-defined, darker brown; a restricted brown cloud on cord and adjoining portions of outer radial veins; veins brownish black. Venation: *Rs* straight, subequal to R_{2+3} which is sinuously bent, narrowing

cell R_1 at its outer end; vein R_{1+2} weak and pale, lying close to the free tip of Sc_2, which, in turn, is about the same distance from the spur of Sc_1; cell R_3 narrowed at about two-thirds its length; basal section of R_{4+5} almost lacking to punctiform, *r–m* likewise reduced; cell *1st* M_2 large, square at base, narrowed outwardly; petiole of cell M_1 about twice *m; m–cu* at near two-thirds the length of M_{3+4}; cell *2nd A* unusually narrow, its greatest width (opposite anal angle) about as long as petiole of cell M_1 or somewhat shorter than *m–cu*.

Abdomen elongate, as shown by the measurements; basal tergites obscure yellow, narrowly darkened laterally, more broadly so dorsally, the amount of dark color increasing on outer segments; vague paler rings at near midlength of tergites two to five, inclusive; posterior borders of segments slightly darkened, the adjoining base of the succeeding segment restrictedly pale at the sides; basal sternites greenish yellow, the outer segments darker; genital shield brownish black. Ovipositor with long straight black cerci, their tips narrowly rounded.

Habitat.—Brazil.

Holotype, ♀, Palmeiras, Estado Rio de Janeiro, November 6, 1940 (Lopes).

The most similar species is *Tanypremna* (*Tanypremna*) *longissima* (Enderlein), likewise from southeastern Brazil. This differs in the larger size (Female, length 55 mm.; wing 22.5 mm.; abdomen alone 48.5 mm.), more especially the longer abdomen in proportion to the wing length. The latter fly is still not known to me except from the original description. From this it is indicated that the præscutum is directed more strongly forward over the head, completely concealing the latter when viewed from above. There are various discrepancies in color between the two flies, including the ovipositor, legs and wings, as the distinctly seamed veins of the outer fourth of the wing in *longissima*.

It is now very evident that there are numerous species of the subgenus in Tropical America, with an apparent concentration of forms in southeastern Brazil. The venation and the basic plan of structure of the male hypopygium indicates that the supposedly very distinct generic groups, *Ozodicera* Macquart, *Longurio* Loew and *Tanypremna* Osten Sacken are, in reality, all closely related and may well be found to pertain to a single major generic group. A very comparable case is found in *Limonia* Meigen, which rather curiously parallels the present condition. Thus, the conspicuously branched antennæ of *Ozodicera* are suggested by one of the subgeneric groups of *Tanypremna*, *Tanypremnodes* Alexander,

where the flagellar pectinations while short are perfectly distinct. The comparable condition in *Limonia* is to be found in the subgenera *Rhipidia* Meigen, *Idioglochina* Alexander, and *Zelandoglochina* Alexander. Furthermore, the delicate, ethereal build of species of *Tanypremna*, as compared to the stouter and more massive condition in *Ozodicera* and *Longurio*, is closely paralleled by various subgeneric groups of *Limonia*, as *Thrypticomyia* Skuse, *Doaneomyia* Alexander, and *Euglochina* Alexander. It is of interest to note that the three typical Tipuline groups listed above have been placed in various tribes and subtribes within the Tipulinæ. The entire subject of genera and subgenera in the more primitive Tipuline crane-flies requires much further consideration and probably will result in a further reduction in the number of supposedly valid generic groups.

Genus *Holorusia* Loew

Holorusia (Holorusia) furcifera new species.

General coloration of mesonotal præscutum testaceous brown, with four more reddish brown stripes that are narrowly bordered with darker, especially the intermediate pair; antennæ (male) relatively long, about one-third the length of body or wing; basal flagellar segments bicolored; thoracic pleura uniformly pale yellow; femora yellow, the tips narrowly brownish black; wings weakly infuscated, with a more whitish central streak as far as the cord; costal border, outer radial field, *m–cu* and a spot in cell *R* brown; cell *1st* M_2 small, irregularly hexagonal; abdomen yellow, with a broad subterminal, dark brown ring; male hypopygium with the outer dististyle narrow, at near midlength bearing a slender lateral branch.

MALE.—Length about 14 mm.; wing 15 mm.; antenna about 5 mm.

Frontal prolongation of head obscure yellow, darker on ventral half; nasus long and conspicuous; palpi black, the terminal segment paling to brownish yellow. Antennæ (male) about one-third the length of body; scape, pedicel and first flagellar segment light yellow; succeeding segments bicolored, the proximal end darkened, with about the distal two-thirds of the more basal segments yellow, the latter color decreasing in amount on the outer segments, on the eighth and remaining segments becoming uniformly brown; flagellar segments cylindrical. Head medium brown, the front and very narrow orbits yellowish gray; a narrow but conspicuous dark brown median stripe on vertex.

Pronotum obscure brownish yellow. Mesonotal præscutum testaceous brown, with four more reddish yellow stripes, the intermediate pair more distinct, margined by narrow, slightly darker brown lines; humeral region slightly darkened, especially internally; scutal lobes chiefly reddish yellow, more obscure laterally; a narrow, darker brown, median vitta that extends onto the extreme cephalic portion of scutellum, the latter pale yellow; para-

scutella more infuscated; postnotum light yellow, the lateral border of mediotergite and the dorsal and posterior borders of pleurotergite somewhat darker. Pleura and most of pleurotergite clear light yellow. Halteres dark brown, the extreme base of stem narrowly yellow. Legs with coxæ and trochanters clear light yellow; femora and tibiæ yellow, their tips narrowly brownish black, the amount subequal on all legs; tarsi passing into black. Wings with the ground color weakly infuscated, variegated with conspicuous darker brown and restricted whitish subhyaline areas; the darker pattern includes especially the costal border, involving the prearcular field; outer radial field as far caudad as vein R_{4+5}; arcular areas; origin of *Rs; m–cu*, and a conspicuous spot in cell *R* beyond midlength of vein *M;* a whitened area in center of wing as far as cord, especially conspicuous across bases of anal and cubital cells, *M* and outer end of cell *R*, crossing the base of cell *1st* M_2; veins brown. Posterior border of wing with scattered black setæ interspersed with the marginal fringe, as common in genus. Venation: *Rs* a little less than twice *m–cu*, angulated at origin; vein R_{4+5} strongly arcuated at near midlength, constricting cell R_3; cell *1st* M_2 small, irregularly hexagonal in outline; *m–cu* close to midlength to vein M_{3+4}; cell M_1 subequal in length to its petiole.

Abdomen yellow, the three subterminal segments brownish black; hypopygium yellow. Male hypopygium with the tergite narrowed outwardly, the lateral angles produced caudad into relatively narrow lobes, the mesal faces of which bear numerous black spinous setæ; median area of tergite notched, at base of emargination produced into a shorter lobe. Outer dististyle narrow, at near midlength bearing a conspicuous slender lateral branch. Inner dististyle with crest high, obtusely rounded; beak broad and obtuse.

Habitat.—Costa Rica.

Holotype, ♂, Pedregoso, altitude 2,075 feet, January 1939 (Dean Rounds).

The present fly is most similar to species such as *Holorusia* (*Holorusia*) *strangalia* Alexander, differing in the small size, details of coloration, and structure of the male hypopygium. The conformation of the outer dististyle is noteworthy.

Genus *Tipula* Linnaeus

Tipula (Eumicrotipula) votiva new species.

General coloration of mesonotum brownish gray, the præscutum with three brown stripes; pleura yellow dorsally, dark brown beneath; frontal prolongation of head yellow above, brownish black beneath; antennal flagellum black; femora with a narrow yellow subterminal ring; wings strongly and almost uniformly infuscated, restrictedly patterned with dark brown and obscure yellow.

MALE.—Length about 8 mm.; wing 8.7–9 mm.; antenna about 3.8–3.9 mm. Frontal prolongation of head yellow above, abruptly brownish black on

sides and beneath; nasus distinct, yellow; palpi dark brown, the incisures pale. Antennæ (male) of moderate length; scape blackened on basal third to half, the remainder yellow; pedicel and flagellum black; flagellar segments scarcely incised, subcylindrical; verticils shorter than the segments. Head brown, more pruinose on front.

Pronotum yellow, the extreme lateral portions dark brown. Mesonotal præscutum brownish gray with three brown stripes that are best-delimited on posterior half of sclerite, especially the broad median stripe; lateral portions of præscutum darkened, including a velvety black spot on margin behind pseudosutural foveæ; scutum dark brown; scutellum and postnotum light brown, sparsely pruinose. Pleura dark brown ventrally, the color including the propleura, almost all of sternopleurite, and the meral region; dorsal pleurites, including the dorsopleural membrane, conspicuously yellow; dorsal anepisternum, posterior portion of sternopleurite and virtually all of the pteropleurite yellow; pleurotergite blackened, especially posteriorly. Halteres with stem yellow, knob brownish black. Legs with coxæ brownish black, sparsely pruinose; trochanters yellow; femora brownish black, brighter basally, with a narrow yellow subterminal ring that is placed more than its own length before the black tip; tibiæ and tarsi black. Wings with the ground very extensively and almost uniformly infuscated, sparsely patterned with obscure yellow and darker brown areas; cell *C* brown, slightly brightened subbasally; cell *Sc* yellow, with four major dark areas that are more extensive than the pale interspaces; more or less distinct creamy areas in prearcular field, beyond arculus in proximal ends of basal cells and as a very faintly indicated area beyond stigma in outer radial field; veins brown, yellow in the flavous portions. No macrotrichia in cells of wing. Venation: R_{1+2} entirely atrophied; R_2 oblique, in direct alignment with R_1 beyond the free tip of Sc_2; petiole of cell M_1 exceeding *m*; cell *2nd A* narrow; venation of medial field very different in the two available specimens; in holotype normal for the subgenus, that is, with M_{3+4} present and with *m–cu* beneath cell *1st* M_2; in the paratype, the venation is almost exactly as in the genus *Nephrotoma*, with *m–cu* uniting with vein M_4 just before the base of cell *1st* M_2.

Abdomen with basal tergites obscure yellow, beyond the first with the lateral borders conspicuously blackened, greatly restricting the amount of yellow; outer segments, including hypopygium, uniformly brownish black. Male hypopygium with the caudal margin of tergite nearly transverse, with a small U-shaped median notch, the lateral portions of the latter slightly produced into small lobes; lateral portions of tergal plate with long abundant setæ.

Habitat.—Bolivia.

Holotype, ♂, Buenavista, Santa Cruz (J. Steinbach). Paratopotype, ♂.

The most similar described species is *Tipula* (*Eumicrotipula*) *fatidica* Alexander, of Ecuador, which differs conspicuously in

the larger size, coloration of the body and wings, the short antennæ, and in the details of venation, as the much wider cell *2nd A*.

Tipula (Microtipula) epione new species.

Allied to *smithi;* mesonotal præscutum and scutum almost uniformly reddish brown; antennæ (male) elongate, yellow, the flagellar segments weakly bicolored; halteres infuscated; legs yellow; wings weakly infuscated, the ground color of outer half of wing more whitish hyaline, heavily patterned with brown, including the broad costal border and outer radial field; R_{1+2} entire; male hypopygium with a single dististyle, its inner angle bearing two or three strong black spinous setæ; lobe of ninth sternite a depressed-flattened quadrate plate, with its apex truncated; eighth sternite with posterior border evenly rounded.

MALE.—Length about 12 mm.; wing 12 mm.; antenna about 7.5 mm.

Frontal prolongation of head brown; nasus stout; palpi brown, the outer segments a trifle darker. Antennæ (male) elongate, exceeding one-half the length of wing; basal three segments yellow; succeeding segments very weakly bicolored, brownish yellow, thè small basal enlargements a little darker brown; segments almost cylindrical; verticils much shorter than the segments. Head brownish gray; anterior vertex at widest point a little exceeding twice the diameter of scape, more narrowed behind between the large eyes.

Præscutum and scutum almost uniformly reddish brown, without markings; scutellum and postnotum more testaceous yellow, parascutella darker. Pleura obscure yellow. Halteres infuscated. Legs with the coxæ and trochanters yellow; remainder of legs yellow, the outer tarsal segments infuscated; claws somewhat weakly toothed. Wings with the ground color weakly infuscated, more whitish hyaline in outer half, including vicinity of cord and outer medial field; a very heavy and conspicuous brown pattern, including the broad costal border which involves the prearcular region, cells *C* and *Sc*, all of *R* excepting the outer end, and virtually the whole outer radial field; conspicuous brown seams on *m–cu* and narrower ones at outer end of cell *1st* M_2 and fork of M_{1+2}; veins pale, darker in the patterned areas. Squama with setæ. Venation: R_{1+2} entire; *Rs* relatively long, about one-third longer than *m–cu*, the latter at near midlength of M_{3+4}; basal section of R_{4+5} very long, greatly reducing *r–m;* cell *1st* M_2 relatively long; cells M_1 and *2nd A* wide.

Basal abdominal segments obscure yellow, beyond the second passing into brown; subterminal segments blackened, forming a narrow ring; hypopygium yellow. Male hypopygium with the ninth tergite long, narrowed posteriorly, the apex terminating in a broad flattened lobe that is gently emarginate, to produce two lobules, both set with conspicuous black setæ; ventral tergal appendage (tegmen) pale and fleshy. Dististyle single, appearing as a subquadrate plate, the outer angle produced into a conspicuous flattened obtuse lobe, its apical border narrowly blackened; inner angle less

produced, at apex bearing two or three long black spinous setæ, the largest of which is about two-thirds the total length of the style itself. Lobe of ninth sternite a depressed-flattened subquadrate plate, slightly widened outwardly, its apex truncated or with vague indications of a median notch, the surface densely setiferous. Ædeagus stout, terminating in a decurved hook-like projection. Eighth sternite extensive, the posterior border broadly rounded, provided with numerous long setæ.

Habitat.—Bolivia.

Holotype, ♂, Buenavista, Santa Cruz (J. Steinbach).

The present fly is most similar to *Tipula* (*Microtipula*) *intemperata* Alexander, *T.* (*M.*) *smithi* Alexander, and *T.* (*M.*) *temperata* Alexander, differing from all in the structure of the male hypopygium. The wing pattern is generally similar in all of these species yet they differ among themselves in the presence or absence of major setæ on the squamæ. In other subgeneric groups of *Tipula* the squamal character has been deemed to be of primary importance in differentiating groups.

Tipula (Microtipula) nicoya new species.

Allied to *perangustula;* size small (wing, male, about 10 mm.); mesonotal præscutum obscure brownish yellow with three black stripes; thoracic pleura yellow, with a narrow, transverse, black girdle occupying the mesepisternum; knob of halteres blackened; claws of male simple; wings with cells basad of cord brownish yellow, the prearcular and costal fields, together with the outer radial cells, strongly darkened; male hypopygium with the lateral lobes of both the ninth tergite and the eighth sternite broadly and obtusely rounded; outer dististyle a simple cylindrical blackened rod; ædeagus not subtended by a pair of spines.

MALE.—Length about 9 mm.; wing 10 mm.; antenna about 4 mm.

Frontal prolongation of head yellow; nasus short and stout; palpi brown. Antennæ relatively long, as shown by the measurements; scape and pedicel yellow; first flagellar segment yellowish brown; succeeding segments black, the incisures of the more proximal ones vaguely brightened; segments only weakly incised; verticils shorter than the segments. Head light brown; anterior vertex wide, approximately four times the diameter of scape, without tubercle.

Pronotum obscure yellow laterally, infuscated on central portion. Mesonotal præscutum with the restricted ground obscure brownish yellow, the surface polished, with three black stripes, the median one relatively narrow; posterior sclerites of notum almost uniformly blackened, the parascutella paler; pleurotergite yellow. Pleura yellow, with a conspicuous transverse brown girdle, extending from the cephalic end of the præscutal stripe which bends laterad to the margin, crossing the dorsopleural membrane and covering most of the mesepisternum. Halteres with stem yellow, knob blackened. Legs

with coxæ and trochanters yellow; femora obscure yellow, the tips rather conspicuously blackened; tibiæ obscure yellow, the tips narrowly darkened; tarsi yellowish brown to obscure yellow; claws simple. Wings with the cells basad of cord brownish yellow; prearcular field, cells *C* and *Sc*, stigma, and cells beyond anterior cord conspicuously infuscated, the last slightly less intense than the others; proximal portions of cells distad of posterior cord and very indistinct markings in bases of cells R_3 and R_5 brighter in color. Venation: R_{1+2} entire but the distal end faint and without trichia; *Rs* relatively short, arcuated at origin, subequal to *m–cu;* cell *2nd A* very narrow, about as in *perangustula.*

Abdominal tergites obscure yellow on their basal portions, the caudal margins broadly black, especially on segments two and three, on the succeeding tergites the amount of black somewhat more restricted; lateral tergal borders darkened; a subterminal black ring; sternites chiefly yellow; hypopygium yellow. Male hypopygium in its general features much as in *perangustula* but differing in all details. Ninth tergite with the lateral lobes broadly and obtusely rounded, with a conspicuous median brush of setæ, in addition to the usual paired ventral tufts; these setæ are much more elongate and less spinous than in allied forms. Outer dististyle a simple, slender, cylindrical, blackened rod, its tip obtuse; setæ relatively short and inconspicuous. In *perangustula,* the style on distal half expanded into an elongate-triangular head, with long coarse setæ. Ædeagus without a pair of subtending slender spines, as in *perangustula.* Eighth sternite with the caudal margin conspicuously bilobed, each lobe obtusely rounded and provided with numerous very long pale setæ.

Habitat.—Costa Rica.

Holotype, ♂, Pedregoso, altitude 2,300 feet, January 1939 (Dean Rounds).

The specific name is that of an Amerind tribe inhabiting Costa Rica. The most similar described species is *Tipula (Microtipula) perangustula* Alexander, of Colombia and Venezuela, which differs especially in the hypopygial characters, as compared above.

Genus *Limonia* Meigen

Limonia (Limonia) curraniana new species.

General coloration brown; anterior vertex silvery; antennal scape yellow, the remainder of organ black; mesonotum brown, with a conspicuous orange dorsomedian stripe; legs dark brown, the tips of the tibiæ and all tarsi with the exception of the terminal segment and proximal portions of basitarsi of fore and middle legs, white; wings strongly tinged with brown; ventral dististyle of male hypopygium without rostral spines.

MALE.—Length about 5 mm.; wing 6–6.2 mm.

Mouthparts very reduced; palpi small, black. Antennæ with the scape pale yellow, the remainder of organ black; flagellar segments gradually narrowed and more slender toward end, the terminal segment about one-half longer than the penultimate segment. Anterior vertex silvery, concave, the anterior vertex several times as wide as diameter of scape; posterior portions of head light brown.

Mesonotum brown, with a conspicuous orange dorsomedian stripe, extending from the anterior portion of the præscutum to the base of the mediotergite. Pleura yellow. Halteres dark brown. Legs with the coxæ and trochanters yellow; femora dark brown; tibiæ dark brown, the tips broadly white; fore and middle legs with the proximal half of basitarsi darkened, the remaining segments, with the exception of the last, white; posterior tarsi white. Wings strongly tinged with brown; stigma not indicated; costal region and barely perceptible seams along cord and over outer end of cell *1st* M_2 darker brown; wing apex insensibly darkened; veins dark brown. Venation: Sc_1 ending just beyond midlength of *Rs*, Sc_2 at its tip; free tip of Sc_2 in transverse alignment with R_2; cell *1st* M_2 short and nearly square; *m–cu* at the fork of *M*, longer than the distal section of Cu_1.

Abdominal tergites dark brown, the basal sternites pale yellow; hypopygium dark. Male hypopygium with the ninth tergite transverse, its caudal border very gently emarginate. Basistyle with the ventromesal lobe extensive, very low and broad. Dorsal dististyle nearly straight, a little expanded before apex, thence narrowed into an acute beak. Ventral dististyle fleshy, the rostral prolongation elongate, gently curved, without evident rostral spines. Gonapophyses appearing as broadly flattened plates, the mesal-apical angle produced into a straight point.

Habitat.—Panama (Canal Zone).

Holotype, ♂, Barro Colorado, January 9, 1929 (C. H. Curran); type in American Museum of Natural History.

I take great pleasure in naming this fly in honor of Dr. C. Howard Curran, distinguished Dipterologist. The species is most nearly related to *Limonia* (*Limonia*) *capnora* Alexander, *L.* (*L.*) *lutzi* (Alexander) and other species but is readily distinguished by the coloration of the legs and wings and by the details of venation.

Limonia (Limonia) mesotricha new species.

General coloration brown, the mesonotal præscutum and scutum variegated with brownish orange; rostrum small, yellow, palpi reduced in size; antennæ black throughout; front silvery; halteres elongate, black; legs black; wings narrowed at bases, strongly tinged with brown; macrotrichia in distal cells; R_2 shortened, the free tip of Sc_2 correspondingly lengthened; male hypopygium with the rostral prolongation of ventral dististyle unarmed with spines.

MALE.—Length about 5 mm.; wing 6 mm.

Rostrum small, yellow; palpi black, very reduced, apparently only 1-segmented. Antennæ black throughout; basal flagellar segments short-oval, the outer ones more elongate; terminal segment one-half longer than the penultimate; verticils elongate. Front silvery; posterior portion of head brownish fulvous.

Mesonotal præscutum with the three usual stripes obscure brownish orange, narrowly margined with brown; scutum with median area pale, the lobes obscure brownish orange, encircled by brown; scutellum dark brown, the median line a little paler; mediotergite with cephalic half brown, the caudal portion brightening to obscure yellow. Pleura obscure yellow. Halteres elongate, black throughout. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs black, the extreme femoral bases restrictedly brightened. Wings strongly tinged with brown, the darker stigmal region restricted to a vague seam over the free tip of Sc_2; vague darker seams over the veins, the centers of the cells paler; veins brown. Wings narrowed basally, long-petiolate; relatively sparse macrotrichia in apical cells from the stigma to cell M_4, inclusive, in most cases being restricted to rows in the centers of the cells. Venation: *Sc* long, Sc_2 ending shortly before the fork of *Rs*, Sc_1 shorter than Sc_2; *Rs* long, angulated at origin; vein R_1 bent strongly caudad, at R_2 approaching vein R_{2+3}, strongly reducing R_2, the free tip of Sc_2 correspondingly lengthened; *m–cu* near the fork of *M*, longer than the distal section of Cu_1.

Abdominal tergites dark brown; sternites obscure brownish yellow; hypopygium chiefly brown, the subterminal segments paler. Male hypopygium with the lobes of tergite somewhat obliquely truncated. Basistyle with ventromesal lobe unusually extensive, occupying almost the entire mesal face of style. Dorsal dististyle straight, slender, the apex a little enlarged and curved into a short point. Ventral dististyle relatively small, fleshy, its rostral prolongation flattened, without evident spines. Gonapophyses pale throughout, the mesal-apical lobe slender.

Habitat.—Panama (Canal Zone).

Holotype, ♂, Barro Colorado, December 21, 1928 (C. H. Curran); type in American Museum of Natural History.

Limonia (*Limonia*) *mesotricha* is very different from all other regional members of the subgenus, particularly in the apically hairy wings. The course of vein R_1, with the accompanying shortening of vein R_2 suggests the even more accentuated conditions found in *L.* (*L.*) *insularis* (Williston) and allies.

Genus *Gnophomyia* Osten Sacken

Gnophomyia (Gnophomyia) podacantha new species.

General coloration black, the head polished, the mesonotum more opaque; anterior lateral pretergites light yellow; thoracic pleura with a broad black

dorsal stripe, the ventral pleurites paler, pruinose; metapleura and posterior coxæ yellow; halteres uniformly blackened; wings with a blackish tinge, the cord and vein *Cu* even more darkened; R_{2+3+4} only slightly elevated; cell *1st* M_2 long and narrow, very little widened outwardly; male hypopygium with the caudal border of tergite truncate, provided with a chiefly double row of approximately one hundred spinous setæ; cephalic end of mesal face of basistyle produced into a long-cylindrical lobe that terminates in two conspicuous black spines; both dististyles narrowed and pointed at their tips.

MALE.—Length about 5 mm.; wing 5.5–5.6 mm.

FEMALE.—Length about 5.5 mm.; wing 5.6–5.8 mm.

Rostrum and palpi black. Antennæ black throughout, relatively long; flagellar segments elongate, with verticils that are subequal to or slightly longer than the segments. Head black, more or less polished; anterior vertex broad, sparsely pruinose, provided with a low tubercle.

Pronotum black. Anterior pretergites light yellow, the posterior pretergites more obscure. Mesonotum black, the surface opaque by a very sparse pruinosity. Pleura with a broad black dorsal stripe, the ventral pleurites paler, pruinose, on the metapleura and meron paling to yellow. Halteres blackened. Legs with the coxæ dark brown, the posterior pair paling to yellow; trochanters testaceous brown; remainder of legs black, the femoral bases paler. Wings with a blackish tinge, the basal third slightly more brightened; stigma narrow, long oval, dark brown; a slightly indicated infuscation along cord and vein *Cu;* veins dark brown, paler in the more basal fields. Venation: Sc_1 ending nearly opposite the fork of R_{2+3+4}; *Rs* short and oblique, in direct alignment with R_5; R_{2+3+4} only slightly elevated; R_{2+3} about twice R_2; branches of *Rs* extending generally parallel to one another for virtually all their lengths; cell *1st* M_2 long and narrow, only slightly widened outwardly, with *m–cu* at about one-third to two-fifths its length.

Abdomen, including hypopygium, black. Ovipositor with elongate cerci, these blackened basally, the distal half obscure yellow; hypovalvæ short, black. Male hypopygium with the tergite large, the caudal margin truncate, provided with a chiefly double row of long spinous setæ, there being approximately 100 or more such setæ; lateral tergal angles produced into lobes, with spinous setæ to their summits. Basistyle at cephalic end of mesal face produced into a long cylindrical lobe that bears two conspicuous black spines at summit, these slightly unequal in length and diameter. Outer dististyle a powerful, nearly straight blackened horn or spike that narrows gradually to the acute tip. Inner dististyle much smaller, broad at base, thence similarly narrowed to the nearly acute apex, before this with a few erect setæ.

Habitat.—Costa Rica.

Holotype, ♂, San Juan Miramar, Pacific slope, in cloud forest, altitude 3,500 feet, January 1939 (Dean Rounds). Allotopotype, ♀, pinned with type. Paratopotypes, 1 ♂, 3 ♀♀.

From other members of the subgenus that center around *maestitia* Alexander and allies, the present fly is readily told by

the very different male hypopygium, especially the armature of the basistyle which has suggested the specific name.

Genus *Neognophomyia* Alexander

Neognophomyia productissima new species.

General coloration of mesonotum reddish yellow; thoracic pleura with a broad interrupted black dorsal stripe, the ventral pleurites pale; wings grayish yellow, with a brown seam on anterior cord; male hypopygium with the tergal spines unusually long and slender, entirely pale, at near midlength narrowed and produced into a long curved needle-like point; phallosome relatively narrow, its apex broadly obtuse to subtruncate.

MALE.—Length about 4.5–4.7 mm.; wing 4.6–4.8 mm.

Rostrum yellowish brown; palpi brown. Antennæ brown, the pedicel slightly brightened; flagellar segments subcylindrical, the outer ones passing into elongate-oval, with very long verticils. Head dark brown, more reddish brown on central portion of vertex; eyes large.

Pronotum obscure yellow above, darker on sides. Mesonotal præscutum shiny yellow, with poorly indicated, more reddish brown stripes, the lateral pair especially distinct, continued backward across the suture onto the scutal lobes; central portion of mesonotum, including the posterior portion of præscutum, scutum and most of scutellum and mediotergite more yellowish. Pleura and pleurotergite on dorsal portion with four disconnected black areas that form a broad broken stripe, these areas located on propleura, anepisternum, dorsal pteropleurite and pleurotergite; ventral pleurites more reddish yellow. Halteres with stem pale, knob weakly darkened. Legs with the coxæ and trochanters yellow, femora, tibiæ and proximal two tarsal segments yellow, the tips very faintly and vaguely darker; outer tarsal segments brownish black. Wings with the ground grayish yellow, the prearcular and costal fields clearer yellow; a relatively broad and conspicuous brown seam extending from the stigma across anterior cord to fork of *M*; much narrower seams on posterior cord and outer end of cell *1st* M_2; veins brown, more yellowish in the brightened fields. Venation: R_2 placed shortly beyond one-third the length of petiole of cell R_3; vein R_4 ending close to wing tip; cell *1st* M_2 rather conspicuously widened outwardly, its proximal end very narrow; *m–cu* at near one third the length of cell.

Basal abdominal tergites broadly yellow medially, conspicuously brownish black on sides; fourth tergite paler than the adjoining ones; tergites five and six conspicuously blackened, seven and eight again pale; sternites chiefly yellow, the outer segments more darkened; hypopygium dark brown. Male hypopygium with the tergal spines unusually long and slender, entirely pale, at near midlength abruptly narrowed into a long curved needle-like point that is subequal in length to the basal section. Outer dististyle relatively short and stout, with about four long setæ at outer end, one apical in position. Inner dististyle short and stout, curved, at apex narrowed into a more sclerotized beak or point. Phallosome relatively narrow, its apex broadly obtuse to subtruncate.

Habitat.—Costa Rica.

Holotype, ♂, Pedregoso, altitude 2,500 feet, January 1939 (Dean Rounds). Paratopotypes, 1 ♂, pinned with type; 4 ♂♂, altitude 2,075–2,300 feet, January 1939 (Dean Rounds).

The most similar described species are *Neognophomyia panamensis* Alexander and *N. trinitatis* Alexander, which have the structure of the male hypopygium somewhat the same. The present fly is readily distinguished by the very unusual elongation of the so-called tergal spines.

Genus *Erioptera* Meigen

Erioptera (Symplecta) macroptera argentina new subspecies.

MALE.—Length about 3.5 mm.; wing 3.8–4 mm.

As in typical *macroptera* (Philippi), differing in the details of structure of the male hypopygium, especially the gonapophyses. Hypopygium with the outer dististyle only moderately expanded at apex, the latter with about a dozen teeth. Inner dististyle slightly longer, appearing as a flattened lobe that narrows gradually to the obtuse tip. Gonapophyses appearing as flattened blades that have about the same size and somewhat the same shape as the inner dististyle, the outer margin with numerous teeth, those toward the base longer and more conspicuous; upper surface of apophysis with smaller denticles. In typical *macroptera* (Chile), the apophyses appear as slender blades, the apical third glabrous and only about one-half as wide as the inner dististyle, the more basal portions of the apophysis with relatively few, very coarse teeth.

Habitat.—Argentina.

Holotype, ♂, Hornadita, Province of Jujuy, altitude 3,400 meters, November 30, 1919 (Vladimir Weiser). Paratypes, 1 ♂, 1 ♀, Bolson, Province of Catamarca, altitude 2,700–2,750 meters, March 7–9, 1924 (Weiser); 1 ♂, Province of Buenos Aires (C. Bruch).

The late Doctor Bruch (Physis, 17: 47; 1939) records the species *macroptera* from La Plata, Delta of the Paraná, Rio Negro and Mendoza. It is presumed that these further records, at least in part, pertain to the present subspecies. In an earlier paper, Bruch (l.c., 17: 26–28; 1939) provides a detailed account, with figures, of the immature stages of this same fly.

A CORRECTION

In the issue of this JOURNAL, Vol. LII, June, 1944, pages 193–199, under the title "A Re-Survey of Papaipema," there was given a contemplated list arrangement of the Papaipema species.

It has developed that in this list a form name, "*ochroptenoides* Benj.," there given as a variety of *P. circumlucens* Sm., was never validated and should be eliminated.

Ample proof of the matter has been furnished by Dr. Carl Heinrich, and Dr. J. McDunnough called attention to the probable error concerning "*ochroptenoides.*"

It may be further remarked that a synonym of *Papaipema frigida Sm., perobsoleta* Lyman, was omitted, also the synonym *imperturbata* Bird, a dwarf form of *P. necopina* Grt., was not listed. Both these synonyms were shortly given their correct status in American literature.—Henry Bird.

THE STATUS AND FUNCTIONS OF THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE AND THE PRESENT STATE OF ITS WORK

By KARL JORDAN, PH.D., F.R.S.
PRESIDENT OF THE INTERNATIONAL COMMISSION

The International Commission on Zoological Nomenclature was established by the Third International Congress of Zoology at its meeting held at Leyden in 1895. The functions then assigned to the International Commission were to study existing unofficial Codes and to make proposals to a later meeting of the International Congress for the establishment of an International Code of Zoological Nomenclature.

After six years' work, the International Commission submitted a draft International Code to the Fifth International Congress of Zoology, by whom the proposed Code was adopted, with certain amendments, at its meeting held at Berlin in 1901. The preparation of the authoritative French text of the Code and of the official English and German translations thereof was completed in 1904 and the three texts were published in 1905.

At Boston in 1907 the Seventh International Congress of Zoology authorised the International Commission to render *Opinions* on questions of interpretation arising from the practical application of the Code. At Monaco in 1913, the functions of the International Commission were extended in two important directions by the decision of the Ninth International Congress of Zoology (i) to confer upon the International Commission the power to suspend the rules in cases where the strict application of the rules would clearly result in greater confusion than uniformity and (ii) to entrust the International Commission with the duty of compiling the *Official List of Generic Names in Zoology*.

As originally constituted, the International Commission consisted of five Commissioners, but in 1898 this number was increased to fifteen. Later it was decided to increase the number

of Commissioners to eighteen, the present number. Members of the International Commission are elected by the International Congress of Zoology, one-third of the Commission (*i.e.*, six Commissioners) retiring at each meeting of the Congress. Retiring Commissioners are eligible for immediate re-election. Vacancies occurring between meetings of the International Congress may be filled by the International Commission itself.

The International Commission have always attached great importance to securing that the principal countries should be represented on the Commission and that, subject to this consideration, the membership of the Commission should include one or more specialists in each of the main divisions of the Animal Kingdom. At the outbreak of war in 1939, the distribution of seats on the International Commission, as between the various countries, was as follows: the United States (4 Commissioners); the United Kingdom (3 Commissioners); Germany (2 Commissioners); and Argentina, Australia, Brazil, Canada, France, Hungary, Italy, Japan and Poland (1 Commissioner each).

The present state of war makes it impossible for the Secretary of the International Commission to communicate with certain of the members of the International Commission, and in consequence it will not be possible for the International Commission to make use of their plenary powers to suspend the rules in any given case until after the war is over, since unanimity in the Commission is required for the use of these powers. In all other matters, the International Commission is empowered to act by a majority and, therefore, can take—and is taking—decisions, notwithstanding the present state of war.

Shortly before the outbreak of the present war, the late Dr. C. W. Stiles resigned the Secretaryship (though not his membership) of the International Commission on grounds of ill-health and on the election of his successor, Mr. Francis Hemming, the present Secretary, the headquarters of the International Commission were transferred from Washington to London. This change rendered it necessary to make new administrative arrangements, including the transfer of the records of the Commission, the raising of funds for the printing of the Commission's publications, etc. At the outbreak of war in 1939, for a time

operations had to be suspended, but in 1942 arrangements were made to resume activities and during the two years that have since elapsed a record number of publications has been issued by the International Commission.

The publications of the International Commission consist of (i) the *Opinions and Declarations* of the Commission, of which together 167 have so far been published, and (ii) the *Bulletin of Zoological Nomenclature*. Thirty-seven *Opinions* and *Declarations* have been published by the International Commission under the new arrangements and many other are awaiting publication and will be issued as soon as possible. In addition, a start is being made in the publication of an annotated edition of the older *Opinions*, the original issue of which has long been exhausted. The *Bulletin of Zoological Nomenclature* was founded in 1943 as the Official Organ of the International Commission to serve as a medium for the publication of cases submitted to the Commission for deliberation and decision, thereby affording zoologists of all countries an opportunity of commenting on any such proposal before any decision is taken on it by the International Commission.

In addition, the International Commission have made arrangements to publish as soon as possible both the *Official List of Generic Names in Zoology* and an up-to-date edition of the International Code of Zoological Nomenclature. The first of these has never previously been published in book form, while of the latter there does not exist any edition containing the latest amendments approved by the International Congress of Zoology.

The publications of the International Commission are obtainable from the Commission's Publications Office, 41, Queen's Gate, London, S.W. 7.

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INDEX TO NAMES OF INSECTS AND PLANTS IN VOLUME LII

Generic names begin with capital letters. New genera, subgenera, species, subspecies, varieties and new names are printed in italics.